

Training Teachers For Integrated Science in Nigerian Secondary Schools

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ABSTRACT

This research examined the teacher training for integrated science in some university departments and colleges in Nigeria with the aim of establishing its characteristics, quality and appropriateness of the training in fitting the trainees to their job. It was decided to focus on all the "players" in the training of teachers; to canvas their views and to investigate their understanding of integrated science as it appears in college and school curriculum.

This study specifically sought to determine:

- (a) the thrust and characteristic features of the teacher training;
- (b) the relevance of the teacher training programme for integrated science students to their role in schools;
- (c) the concepts of integration implied and reflected in both the junior secondary school national core curriculum for integrated science and in the curricula for teacher training; further to compare and contrast the views found;
- (d) the perception and understanding of "integration of science" in schools held by practising integrated science teachers, student teachers and the teacher trainers.

The integrated science curriculum in schools; and the curriculum used in the training colleges and the universities were also analysed to compare and contrast the integration models used to structure them.

By means of questionnaires and interviews in schools, colleges and universities in Nigeria, data were collected and analysed describing the views, understandings and practices of integrated science teacher trainers, classroom (practising) teachers and the student teachers in selected schools and training institutions in Nigeria. A total of two hundred and sixty four (264) participants responded to the questionnaires.

In the light of the research findings, their discussions and implications, the following conclusions and recommendations have been made, that:

1. There is a general low understanding of the meaning and the philosophy for integrated science education among the participants. The term "*integrated science*" was defined by most participants popularly as the teaching of the sciences of biology, chemistry and physics mixed together.
2. The student teachers, most of whom had weak background in the pre-requisite sciences, saw their training curricula as overloaded and not appropriately matched to the duration of their training and needs. However, students from training institutions that were under the Nigerian Integrated Science Teacher Education Project (NISTEP) were relatively more positive and optimistic about their training.
3. There is a dearth of relevantly trained integrated science practising teachers in schools as well as teacher trainers in the training institutions in Nigeria.
4. The Junior Secondary School curriculum for integrated science revealed a substantial amount of evidence to show that it was designed with relevance to the child's needs, environmental conditions in Nigeria and reasonable meaning of integration in scope and intensity. The NISTEP curriculum appear to be a good model for the training of teachers to implement the JSS curriculum. Those of universities are more or less ambitious.

It is recommended that a systematic programme of teacher training for integrated science be mounted to meet the need of the junior secondary schools as well as the teacher training institutions. First, a rigorous orientation and training of the teacher trainers in the meaning, philosophy and the methodology of integrated science education. The Science Teachers Association of Nigeria (STAN) and the National Commission for College of Education (NCCE) can work together to achieve this goal. The NISTEP human and material resources and the STAN Integrated Science Panel can be invaluable vehicles in meeting both the full time and INSET training needs.

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CHAPTER I

INTRODUCTION.

The period between 1959 and 1969 was characterised by activities in many parts of the world to develop new and suitable science curricula for the primary schools and junior classes of the secondary school. The consequence of this, was a world-wide educational revolution in the area of science education aimed at effecting changes either in the education structure itself, the content of educational programmes or even instructional methods. In America, for instance, the American Association for the Advancement of Science (AAAS), developed new curricula. Prominent among these curricula are: Science-A process Approach (SAPA), Physical Science Study Committee (PSSC), Biological Sciences Curriculum Study (BSCS) and the Chemical Education Material Study (CHEM Study) (Harbeck (Ed), 1976). In the United Kingdom, the Nuffield Science Teaching Project initiated many science education reforms. In Africa, apart from the efforts of various Ministries of Education in Kenya and Nigeria, the African Primary Science Programme (APSP) of the Education Development Centre was founded with the aim of assisting participating countries in the development of materials and methods suitable for the introduction of modern science instruction into the primary schools.

These various efforts are indeed justified in view of the vast expansion of scientific knowledge, its attendant effects and its relevance to our lives.

The UNESCO harnessed these various curricular efforts by convening a planning meeting in integrated science teaching in Paris from the 17-19 March, 1969. This meeting used as its basis the aspiration for integrated science teaching at the primary and junior secondary levels set forth in the CIES report of the Congress on integrated science teaching which took place in Varna, Bulgaria, Sept. 1968, and the final report of the regional workshop on UNESCO/UNICEF assisted projects in science education in Asia, Bangkok, Nov., 1968.

This upsurge in curriculum reform could be said to be an outcome of several factors. In explaining some of these factors, Okunrotifa,(1980) said :

apart from the continuing explosion of new knowledge which increases the rate of obsolescence of school curricula, the break down of interdisciplinary boundaries, particularly in the sciences, has given new dimensions to contemporary education. New fringe disciplines and fields of knowledge have arisen, the horizons of traditional disciplines have expanded and techniques developed in one discipline are being applied in others. There was a need therefore to reflect these changes in the curriculum.

During these early periods of the introduction of science teaching in schools worldwide in which some forms of physics, chemistry and biology were taught particularly at the lower level of the secondary school, it became clear that science was being treated as a fragmented perspective of the environment and more attention was given to the acquisition of the end products of science, such as facts, rules, laws and principles. The process component of scientific training that offers the opportunity for skill and attitude development was overlooked and most of the pupils' learning activities were centred on experiments and observations that verified known scientific laws and principles (Cole,1989). Curricular reforms were therefore directed at addressing such lapses as this.

The reforms were also to accommodate the new emphasis in science education which has shifted from the heavily biased goal of producing only the elite minority of scientists, technicians and engineers for industrial growth to one of promoting scientific literacy and critical thinking ability among a whole population. Kirk, (1973); Lambert, (1979) and Sabar, (1978) expressed the need for the education of the general public through science. Every individual, they said, has the right to education of which science is a segment. This buttresses the point of scientific literacy advocated for by many people. For example, it is the belief of Showalter (1979) that a scientifically literate person:-

- 1.- understands the nature of scientific knowledge;
- 2.- understands and accurately applies appropriate science concepts in interacting with his or her universe;
- 3.- uses processes of science appropriately in solving problems, making decisions and furthering his or her own understanding of the universe;

- 4.- understands the values that underlie science and consciously chooses to apply them or not in interacting with his or her universe;
- 5.- understands and appreciates the joint enterprise of science and technology and the interaction of these with each other and with other aspects of the society;
- 6.- has developed a richer more satisfying and more stimulating views of the universe as a result of his or her education in science and seeks to extend this education throughout life;
- 7.- has developed numerous manipulative skills associated with science and technology;
- 8.- has developed an ability to think on the formal operations level as described by Piaget and others.

The present trend in integrated science therefore seemed to be going beyond mere integration of science disciplines to accomplish the task of general science education.

In Nigeria, the Science Teachers' Association of Nigeria (STAN) spear-headed the science education curriculum reforms. The Association, in an attempt to make science accessible to a more significant population of Nigerian children in the lower forms of our secondary schools, and in response to the call to make science more relevant to the needs and aspirations of our developing society, developed the first phase of integrated science curriculum for use in the junior secondary schools. In developing this integrated science curriculum, considerable attention was paid to such questions as :

- (a). Why do we teach science?
- (b). Is the science we teach appropriate and relevant to the scientific and educational needs of our children and of our society?. This second question was considered in three main parts:
 - i. Are we taking sufficient account of individual differences such as the range of abilities, aptitudes and the varying environmental factors operating on the child, in our science teaching?
 - ii. Are we teaching our science in a manner that makes it meaningful to, and has a lasting effect on our pupils not only in the strictly scientific sense, but in a way that has a general educative and practical values for our children?
 - iii. Is the subject matter of our science teaching best suited to the needs of our children and our society? (STAN Curriculum NewsLetter No.1, 1970)

The traditional assumptions made in respect of such questions have been that science teaching was mainly concerned with imparting of factual knowledge. Further, the content of science education should be fairly uniform all over the world even including biological sciences. The accumulation of experiences in science education over the years,

however, has shown that neither of these assumptions is valid. For a purely factual approach to science has little lasting impact and the needs of people, in respect of science educational content, are now known to vary quite widely from place to place (Foecke,1974).

The STAN integrated science course defined the aims of the course not only in terms of the factual knowledge to be acquired by the pupils, but also in terms of the ultimate modes of behaviour of the pupils both in their approach to problems in their science studies at school and in the larger world of their working lives. The document concluded with a recognition of the role of the teacher when it said:

In attempting to achieve these aims, it must be borne in mind that qualification and professional training of the teacher, whose task is to teach the course, cannot be overlooked.

1.2 BACKGROUND AND STATEMENT OF THE PROBLEM.

Performance of teachers in the Integrated Science enterprise is currently out of tune with the philosophy of the Nigerian Integrated Science education. This has precipitated a crisis situation in the classrooms thereby raising serious doubt about the accomplishment of the objectives of the Integrated Science programme. The point is made that the crisis hinges on lack of appropriate training for teachers coupled with a seeming apathy by most universities towards Integrated Science education...

(Maduabum, 1990)

Teachers are the pillars of support in the implementation of programmes in any educational system. There appears to be a one-to-one correspondence in the success or failure of an educational programme and the strength or weaknesses of the teachers in the system as “no education system can rise above the quality of its teachers” (Fed. Rep. of Nigeria, 1981). It is apparent therefore that the quality of integrated science teaching in the schools cannot rise above the quality of the integrated science teachers.

The birth of integrated science education into the Nigerian school curriculum was not accompanied simultaneously by any corresponding programme of teacher education. For even after about a decade of introducing the new curriculum into the classroom, institutionalised teachers' training programmes did not include courses in integrated science

(Jegede, 1981). The assumption then as now was that any teacher who had a qualification (degree or NCE) in any of biology, chemistry, physics, the earth sciences and mathematics, could teach integrated science. Teachers with qualifications in single science disciplines or some elementary background knowledge in science were being indiscriminately assigned to the teaching of integrated science, and of course, without any form of initial preparation or guidance for the task. Teachers are being asked to teach what they have neither learnt nor have been trained to teach. In fact, teachers who have been taught science only in specialised packages and might have also been taught by methods which probably have stressed lecture and memorisation and avoiding direct involvement in experimental work are now being expected to depart completely from this background and teach science in both an integrated and inquiry- oriented manner. How is this miracle expected to happen?

Studies conducted on the attitudes and performances of integrated science teachers in Nigeria, however, have been quite revealing. For instance, studies carried out by Odubunmi (1981), Mani (1981), Olarewaju and Balogun (1984), to survey the teaching methods being employed by some teachers of integrated science, found that lecturing and note taking dominated the school lessons.

Reporting his own research experience, Olarinoye (1983), observed that most of the integrated science teachers show and express their biases in teaching the contents of the curriculum. They were found to be active and interested in teaching those content areas within the disciplines in which they are specialised. Such teachers could not therefore handle effectively those areas on the curriculum considered to be 'foreign'.

Studies were also carried out to find out what concepts of integrated science was held by pre-service and in-service teachers of integrated science. The finding revealed that it is popularly held by most teachers of integrated science that the subject is merely a combination of biology, chemistry and physics, (Olawaju, 1983; Jegede, 1983; Akinmade, 1988b). Very recently Jegede (1989) reported a study in which integrated science students were asked to assess their teachers for characteristics of effective teaching. Part of the results showed that quite a large number of teachers have been assessed by their students as

...spending too much time giving us facts and information instead of practical experimental work, ...do not make adequate plans for the laboratory activities, and ... do not collect necessary materials for laboratory activities.

It would appear that all is not well with the integrated science enterprise in Nigeria. It is also a strong pointer to the fact that, if integrated science education in Nigeria is to achieve its intended goals, there is certainly a crucial need for an appropriate teacher education. A number of teacher training institutions (Colleges of education and the Universities) have realised this need and have picked up the challenge to educate teachers of integrated science. Although the efforts are commendable, practices have been far from uniform. While the Nigerian Universities evolve separately their own integrated science curricula, the Colleges of Education have recently been brought under a single management of a federally constituted "National Commission for Colleges of Education" (NCCE). The commission, charged with over-seeing the programmes of all colleges of education in the country has recently designed a national core curriculum for all subjects including integrated science, for the education and training of teachers in all colleges in the country. This, in fact, was the beginning of harmonising programmes at the colleges of education level which, hitherto, a few of our universities, through the different instruments of affiliation, have ministered to their academic and certification needs.

Today, these trained integrated science 'specialist teachers', though few in number, are serving in various capacities in our primary and secondary schools. It can be assumed that these specialist integrated science teachers have varied background and experiences from their trainings, since the training institutions, in particular the universities, do not operate a unified training scheme. Furthermore, a complication in the training of integrated science teachers at some of the training institutions may arise from the lack of adequately qualified science educators. As it is most often than not, a number of these teacher trainers are themselves single science professionals with very little or no experience at all in the meaning, philosophy and objectives of integrated science teaching. Furthermore, a good number of these teacher trainers may also lack strong professional background in education and experience with which to guide the student teachers, exacerbating the problem.

This study is therefore attempting to carry out a survey of the institutionalised training programmes for the pre-service teachers of integrated science in Nigeria. The study will specifically attempt to determine the present state of the training as well as attempt to establish the adequacy and appropriateness of the training programmes for the task of integrated science teaching in Nigeria. The adequacy and appropriateness of the programme will be considered in terms of relevance structure , experiences and duration of the programme. The survey will focus on both the universities and colleges of education examining the type and nature of training for the teachers of integrated science- what is being done, how it is done and perhaps, reasons for doing it that way.

Specifically, the study will attempt to focus on the following questions:~

1.2.1 Research Questions:

1. How is the concept of integration portrayed in:-

- (a) the Nigerian integrated science core-curriculum for the Junior Secondary School?
- (b) the Nigerian core-curriculum for teacher training in the colleges of education?
- (c) the B.Ed integrated science teacher training curricula in the Nigerian universities sampled for this study?

2. Is there any relationship between the teacher training curricula and the curriculum for which the teachers are being prepared to implement?

3. What are the characteristic features of the integrated science teacher training programmes in the selected colleges and universities?

4. How do the trained and untrained integrated science classroom teachers perceive integrated science and its teaching in school?

5. Is there any difference in the way the integrated science student teachers and their trainers perceive integrated science and its teaching in school?

1.3 PURPOSE OF STUDY.

This study aims at examining the nature, quality and the appropriateness of the education being given to pre-service teachers of integrated science to prepare them for the effective implementation of the Nigeria integrated science core-curriculum for the Junior Secondary Schools. The study is hoped to serve as a basis for identifying the main characteristic features of teacher education programme for integrated science teaching in Nigerian. Efforts will be made to identify the strengths and weaknesses in the programmes with a view to making proposal⁹ for possible improvement strategies.

1.4 SIGNIFICANCE OF THE STUDY.

The importance and role of science in a developing country like Nigeria cannot be over-emphasised. This model is based on the assumption that nations which have attained greatness in science and technology have paid great attention to the appropriate management of all the factors that are in interplay within an educational system - the curriculum, pupils, teachers, educational policy makers etc. For instance, an Asian Policy Paper "Asian Model Education Development: Perspectives for 1965-1980"(Ajakaiye, 1989) states

...it is the application of science and technology that has made it possible for the advanced countries of the world to banish poverty and provide a high standard of living. A similar scientific and technological revolution would have to be brought about in Asia if a new social order that would provide abundant life for all is to be created.

Nigeria's shift in emphasis towards scientific and technological development would not only require the development of a relevant science curriculum, but would also require a sizeable number of trained personnel to staff the programme. The teacher factor in particular is an indispensable determinant of the successful implementation of any curriculum innovation. Stake et al, (1978), succinctly put it :

what science education will be for any one child for any one year, is most dependent on what the child's teacher believes, knows, and does - and does not believe, does not know and does not do. For essentially all of science learned in school, the teacher is the enabler, the inspiration and the constraint.

Jegede (1981), observed that the Nigerian situation appears to be a case in which the teachers of integrated science are being asked to teach what they have not learnt. By the philosophy and nature of integrated science, it is obvious that it demands much from the teachers. A large number of these science teachers present in our classrooms today have learned science in separate specialisation and by other methods believed to be alien to those used in modern integrated science courses, yet they are expected to completely adapt to the demands of integrated science courses with very little guidance. It is, therefore necessary that the teachers of integrated science be given the appropriate kind of training that will make them feel more comfortable and confident with implementing the subject. The training should not only help the teachers to build confidence but also to acquire the competence to handle their work effectively to meet the desire^d/goal of the programme. Integrated science which is student and activity oriented - a 'hands on' approach to our science teaching, requires at least in part that the teacher be taught in like manner.

How successful the Nigerian core-curriculum implementation will be towards achieving its goals depends to a large extent on the classroom teachers who will attempt to translate the theory into practice, making integrated science both relevant and interesting to the learner. The science teacher is expected to function as a facilitator and a catalyst to education in general" (ASE, 1971). Faure (1972) in Owoseye (1983), believes that the teacher will have to become more and more an adviser in the classroom, a partner to talk to, he will have to devote more time and energy to be productive and creative. Sawyer (1980) added that the teachers are the key to development and sustenance of interest in science if only they are able to weave science taught in schools on to the knowledge of ideas children bring with them to school. In this way the inter-play between the expected and the surprising may be capitalised upon in producing teaching-learning situation.

Reflecting on this highly demanding role expected of the science teacher, it is obvious that the teacher requires help in order to build the necessary competencies that will enable him perform his role confidently and effectively. This concern underscores the importance of this study.

1.5 THE NIGERIAN SYSTEM OF EDUCATION: a brief review.

This section gives a synopsis of the Nigerian system of education; its philosophy, objectives, structure and organisation. A historical development and status of science education in the school curriculum in Nigeria is described.

Philosophy -The National Policy on Education states that the philosophy of Nigerian education is based on:

the integration of the individual into a sound and effective citizen and equal educational opportunities for all citizens of the nation at the primary, secondary and the tertiary levels, both inside and outside the formal school system. (Adaralegbe, Ed. 1972 ; Fed. Govt of Nigeria. 1981).

Objectives - The aims and objectives of the national policy on education to which the philosophy is linked are:-

1. the inculcation of national consciousness and national unity;
2. the inculcation of the right type of values and attitudes for survival of individuals in the Nigerian society;
3. the training of the mind in understanding the world around;
4. the acquisition of appropriate skills, abilities and competencies, both mental and physical, as equipment for the individual to live and contribute to the development of his society.

The system of education being operated in Nigeria is known as the 6-3-3-4 which identifies the years spent in successive phases of education.

1.5.1 The 6-3-3-4 System OF Education : Structure and Organisation.

1.5.1.1 Primary Education

Six years of primary education are given to the children who must have attained the age of six at the start of this phase. This stage has an objective of broad-based education.

1.5.1.2 Secondary Education

This phase is given in two stages; Junior Secondary School and Senior Secondary School, each of three years duration (total of six years); hence the 3:3 system described in

the title. The broad aims of secondary education are as a preparation for useful living and for higher education. The two phases are described as follows:

The Junior Secondary School education: It is both a pre-vocational and academic course. Every student is offered the following subjects:- mathematics, English (language and literature), language of the environment, one major Nigerian language , integrated science, social studies, creative art (music & art), practical agriculture, religious studies, physical education, and any two pre-vocational subjects (introductory technology, local crafts, home economics & business studies).

Examination and certification of pupils are based on the continuous assessment method together with an end of course examination conducted by the appropriate Ministry of Education leading to the award of the Junior School Certificate (J.S.C.).

The Senior Secondary School Education: At the end of the Junior Secondary School education, successful students may proceed to the second stage of secondary education. There are three types of institutions at this stage:

1. Senior Secondary Schools;
2. Technical Colleges;
3. Teachers' Colleges.

Placement of the child in any of these depends on his/her ability, aptitude and interest.

The curricula of Technical Colleges and Teachers' Colleges are geared towards craftsmanship and teacher training respectively. In Senior Secondary Schools however, all students must compulsorily offer the following subjects:-

English language;

Mathematics;

One Nigerian language;

One of chemistry, physics and biology;

One of literature in English, history and geography;

Agricultural science or a vocational subject.

In addition to the above, students must offer three elective subjects, not already offered as one of the core subjects, and may drop one of these electives in the third year. The elective subjects are, additional mathematics, agricultural science, auto-mechanic, arabic studies,

biology, bible knowledge, book-keeping, chemistry, commerce, economics, electronics, English literature, fine art, french, geography, government, health science, history, home economics, islamic studies, metal work, music, physical education, physics, short-hand, technical drawing, typing and woodwork.

Examination and certification are based on the continuous assessment together with a national examination conducted by the West African Examination Council (W.A.E.C.) leading to the award of the Senior School Certificate (S.S.C.).

1.5.1.3 Higher Education.

This is a stage for specialisation, the minimum entry qualification being the S.S.C. Higher Education is, therefore, a post-secondary education, given in either a university, a polytechnic, a college of education or a school of agriculture, forestry, nursing school, etc.. Most basic courses in the university run for four years, colleges of education run three years courses leading to the award of the Nigeria Certificate in Education (N.C.E.). The polytechnic courses are in two phases, each of a two year duration leading to the award of the National Diploma (N.D.) and Higher National Diploma (H.N.D.) respectively. The educational programme is summarised in Figure 1.1 below.

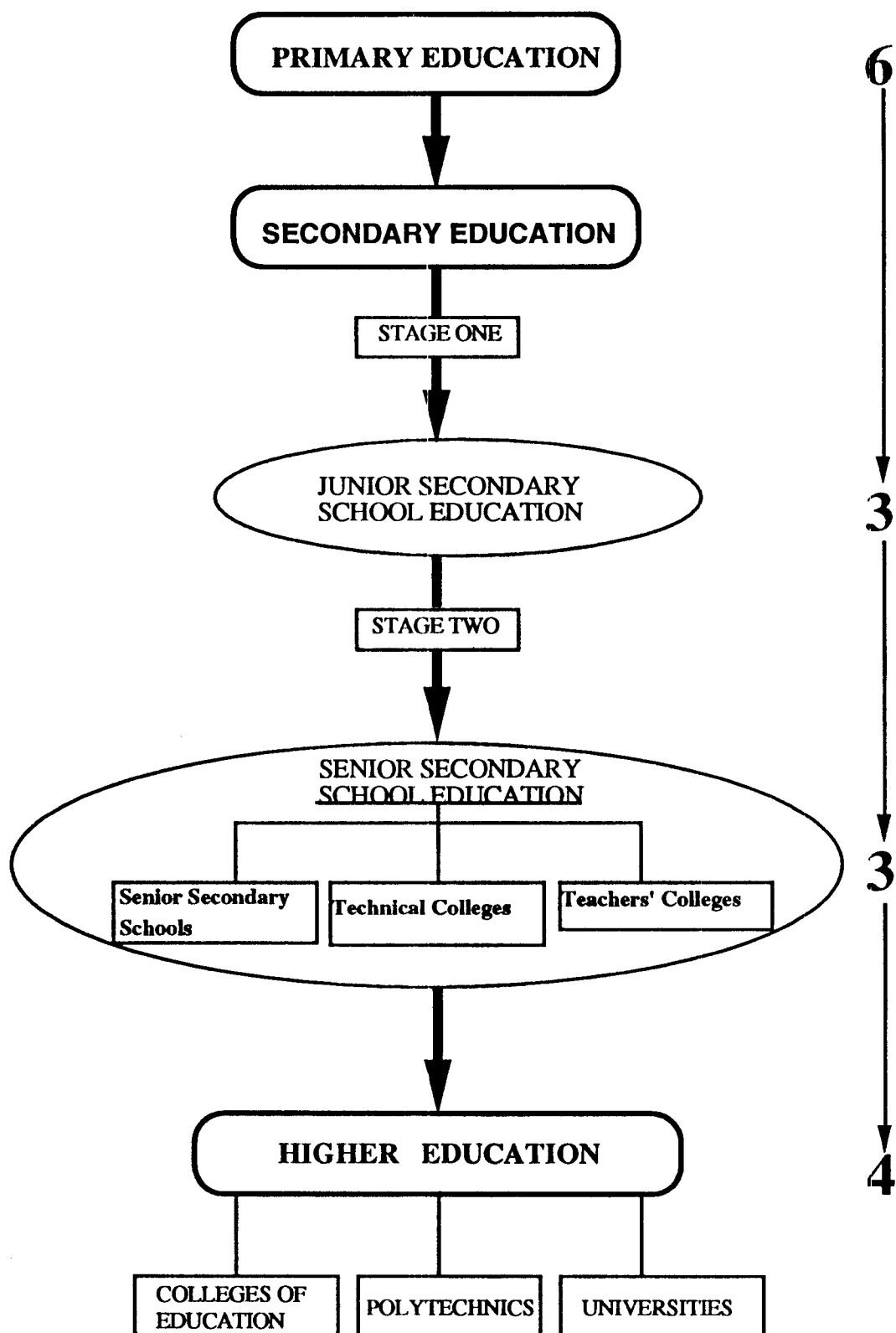


Figure 1.1 The Nigerian 6-3-3-4 System of Education

1.6 THE EMERGENCE AND DEVELOPMENT OF SCIENCE EDUCATION IN THE SCHOOL CURRICULUM IN NIGERIA.

Although western education was introduced to Nigeria in 1843 when the first known primary school was established by the missionaries, the history of modern science teaching in Nigerian schools is very recent. The trend of science education in Nigeria, unlike most western countries, where science teaching grew from the universities to the high schools, in Nigeria science has its roots in the primary schools (Abdullahi, 1982).

According to Omolewa (1977), even when the missionaries were establishing post-primary institutions in the second half of 19th century, there were few attempts at science teaching. Rudiments of science, he said, were introduced by missionary doctors and other science enthusiasts who were influenced by the developments in Britain where science was gaining popularity through the efforts of such pioneering science lecturers as Perkins, Faraday, Dalton, Joule and Bunsen. He concluded that the general method of science teaching employed by these missionary science enthusiasts in Nigeria, like the early British science teachers, was not based on practical classes.

Until the beginning of 1930s, science teaching in most Nigerian schools was a 'glorification of nature' (Abdullahi, 1982). However, as from 1928 when the School Certificate Examination was introduced into Nigeria with Oxford and Cambridge Examination Boards as moderators, the secondary schools in Nigeria began to adapt the syllabuses for English high schools in the teaching of science. In view of the difficulty in securing trained science teachers and resources for science teaching, there was lack of uniformity in science teaching. While some schools were offering general science which consisted of biology, chemistry and physics, taught as a basic course leading to the school certificate level, other schools taught general science at the lower forms and in senior classes, students could specialise in biology, chemistry and physics.

1.6.1 General Science.

The concept of general science as a subject to be offered up to the school certificate, has its historical source from Britain whose educational system Nigeria inherited (Taiwo, 1975, Abdullahi, 1982). They explained that, in 1937, the British Associations (the Science Masters Association & the Association of Women Science Teachers) published a policy paper titled "General Science in schools" (Lucas & Chisman, 1973). The paper argued that as much as knowledge of general science forms an essential part of a liberal education, it should be taught in all secondary schools. Among other things, the general science course was designed to meet the following objectives:-

1. As a means not merely of giving the child a lot of scientific information, but also of developing in him certain attitudes and skills such as accurate observation, logical reasoning, and desire to experiment.
2. General science would deal with the every day application of science.
3. General science should show the unity of science rather than the compartmentalisation of science into separate disciplines such as biology, chemistry and physics.

Thus by 1950 most Nigerian secondary schools were offering general science in one form or the other but the general trend was to offer it as a single subject up to the School Certificate Examination partly because of the dearth of science teachers in single subject areas and mostly because of the lack of resources needed to teach basic sciences up to the School Certificate level. However, by the mid 1950s, general science in Nigerian schools began to experience a failure as an approach to science teaching for the following reasons:-

1. When Higher School Certificate (H.S.C.) courses were started in the more developed secondary schools, students who had successfully completed School Certificate General Science could not be easily accepted into the H.S.C. course to study biology, chemistry, physics except they gained a distinction in the course.
2. General science at the school certificate level was regarded as a 'soft option' - seen to be less demanding than the separate disciplines, not only in the coverage but it was also thought to be less demanding intellectually.

3. The teachers often taught the topics in which they possess competence in, hence in some schools it was not uncommon to find three teachers assigned to the same general science course.

Consequently, by the mid 1950s, most Nigerian schools had returned to the science education pattern with a two - tier approach in which general science was taught in the first two years to every student in a five year secondary school education programme. Students are subsequently allowed to specialise during the last three years so that those who desire careers in science could choose two or three basic sciences depending on their abilities. Furthermore, students who want to specialise in Arts subjects, select one science subject to meet the requirements of the School Certificate Examinations. Today, science subjects have not caught up with Arts subjects in popularity. Despite deliberate efforts to obtain a ratio of 60:40 between science and Arts subjects respectively in post primary institutions, science subjects are still very low and far below Arts subjects in enrolments (Abdullahi, 1982; Ajakaiye, 1989).

The West African Examination Council (W.A.E.C.) was established in 1950 to take over the functions of the Oxford and Cambridge School Certificate Examinations Boards. From that period, according to Abdullahi, changes were introduced "to reflect the need to indigenise the contents and scope of science teaching in Nigerian schools." He described the then science syllabuses as reflecting British requirements and aspirations rather than Nigerian and that most activities in science teaching were beyond the experience of the Nigerian students.

In an effort to popularise science in schools, science teachers all over the country met and inaugurated the Science Teachers Association of Nigeria (S.T.A.N.) in 1957. It is this association which saw to the emergence of Integrated Science as a subject to be taught in the junior forms. The successful introduction of the Integrated Science into the junior forms resulted in a shift in the objectives and methods of science teaching in our secondary schools. The S.T.A.N. Integrated Science Project was concerned with the teaching of science through inquiry and discovery approach in which students come to understand and develop science concepts by investigating and experimenting on their own.

By the turn of 1980s, it has become recognised that science is not only an academic discipline for scientists, not only as an important tool of industry, medicine, agriculture, but also an important instrument for making socio-political and economic decisions. Science, we are reminded, is a way of life which cuts across all social, cultural and political boundaries (Bajah, 1982). Thus, a target of 'science for all' became the guiding principle for science education at the elementary level. This objective, among others, gave impetus to the emergence of the many integrated science education of which the Nigerian Integrated Science Project (NISP) is one. The next chapter reviews the historical development of this project.

1.7 DEFINITIONS OF TERMS/ ABBREVIATIONS

Federal university or college or school - These are institutions established and run by the Federal Government of Nigeria, the direct administrative organ being the federal ministry of education.

Private School - A secondary school that has been established by an individual and have that individual as its sole proprietor. Such a school may or may not benefit from any government grant.

Voluntary Agency School - This is a secondary school established and managed by a corporate body such missionary organisation, community association etc.

National university Commission (N.U.C) - A body set up by the Federal Government of Nigeria and charged with the responsibility of making policies as they affect the establishment and running of universities (private or Government) in Nigeria.

Federal Character - A political term describing the ethno-geo-political factors often used as the yard stick for sharing the 'National Cake' to the states of the federation. The 'national cake' could be economic distribution, educational opportunity and other such human needs.

Practising Teachers - These are integrated science teachers who were on permanent teaching appointments in the secondary schools at the time of data collection for this research.

Teacher Trainers - These are teachers in the colleges of education and universities who are involved with the training of integrated science teachers in Nigeria.

Student Teachers - These are students undergoing preservice teacher training for integrated science teaching.

Joint Admission and Matriculation Board (JAMB) - This is a body set up by the Federal Government to take care of admissions into all the universities in Nigeria.

UNESCO - United Nations Educational, Scientific and Cultural Organisation.

UNICEF - United Nations Children Education Fund.

STAN - Science Teachers Association of Nigeria.

NCE - Nigeria Certificate of Education.

NCCE - National Commission for Colleges of Education.

WAEC - West African Examination Council.

NISP - Nigerian Integrated Science Project.

CESAC - Comparative Educational Study and Adaptation Centre.

CREDO - Curriculum Renewal and Educational Development Overseas.

ICSU - International Council of Scientific Union.

NISTEP - Nigeria Integrated Science Teacher Education Project.

CHAPTER 2

THE NIGERIAN INTEGRATED SCIENCE PROJECT (N.I.S.P.)

We have understood from the previous chapter that the Science Teachers Association of Nigeria (STAN) spear-headed the science education curriculum reforms in Nigeria. The Nigerian Integrated Science Project was the brain child of this association aimed at introducing a Nigerian version of integrated science education to the lower forms of the secondary school.

This chapter discusses the evolution and introduction of integrated science into the Nigerian school system. It has been put together from the records of the Science Teachers Association of Nigeria (S.T.A.N.) (1970), Jegede, (1981), and Bajah (1982). The subsequent development of integrated science as a school subject to its present status and reports of evaluation exercises on the NISP are also discussed.

Integrated Science was not a school subject in Nigeria until the early 70s when it was introduced by the Science Teachers Association of Nigeria (STAN). The story for the emergence of integrated science as a school subject says that it started early in 1968 when a request was received by S.T.A.N. from the West African Examination Council (W.A.E.C.), that S.T.A.N. should make recommendations to the Council for revision and improvement of the current West African School Certificate science syllabuses. This was felt to be necessary in the light of modern developments in science education and in view of the rapid changes occurring in scientific knowledge. Furthermore it was felt that with the up-dating of the Higher School Certificate (H.S.C.) syllabus, the gap between the West African School Certificate (W.A.S.C.) and the H.S.C. was widened and so an up-dating of the W.A.S.C. syllabuses would help to bridge the gap. In response to the request, the National Executive Committee of STAN constituted three curriculum development committees one each in biology, chemistry, and physics in May 1968. Later that year, a fourth committee, the mathematics committee was also constituted by STAN. The terms of reference of these curriculum development committees were set out as follows :

- i. To review and revise the existing science and mathematics syllabuses.
- ii. To produce teachers and pupils materials relevant to the revised syllabuses.
- iii. To perform such other functions connected with science curriculum development as the STAN Executive may from time to time direct.
- iv. To cooperate with any other science curriculum development groups to achieve these ends.

2.1 THE BIRTH OF N.I.S.P.

At one of the Executive committee meetings, a member wanted to know the foundation on which the science syllabuses for the WASC, now under review, were to be built. In effect, he wanted to know what kind of assumed scientific knowledge and processes the students who would use the newly developed syllabuses possess. The answer to this basic question which to some members looked obvious but proved not to be so obvious, was indeed the beginning of the Nigerian Integrated Science Project (Bajah, 1982). A major break through that was to change the course of events came when some members of the committee reasoned along this line and concurred that whatever materials they finally developed in the chemistry, physics and biology for the higher forms of the secondary school would presuppose a sound basic foundation in science in the junior forms. They contended that no matter how good their materials were, if the students who would use them do not have a balanced nationally uniform science background, all their efforts would be in vain. This position marked the turning point! After a series of brain storming meetings, it was then agreed that if STAN so desired, it could develop the integrated science programme on its own and this eventually led to the birth of the NISP. The various subject committees were then mandated to select representatives to an all embracing integrated science curriculum committee. This committee was then charged with the responsibility of producing the relevant materials for the integrated science.

The newly constituted integrated science committee published its first document in January, 1970 [Howell G.(Ed).1970], under the caption "Curriculum Development Newsletter No.1". This document, which contains statement of philosophy, methodology,

content and evaluation of integrated science, is a course for the first two years of Nigerian secondary school. Firmly rooted in the ideas expressed in this document are fundamental issues of integration in science. The Curriculum Development Newsletter which was the first document to lay down the blue print for Integrated Science teaching at the junior secondary school level in Nigeria, identified a number of aims for the course. These aims were largely predicated on the "modes of behaviour" that should be expected of a child as a result of his/her "school science work". Hence the aims specified that the course should enable the child to:

- (a) be actively involved in the learning process;
- (b) develop the motivation and the ability to work and think in an independent fashion;
- (c) recall information and experiences;
- (d) devise scheme for solving problems;
- (e) use and classify given information;
- (f) apply previous knowledge to new situations;
- (g) interpret information showing evidence of judgement and assessment;
- (h) communicate selectively and effectively;
- (i) relate his experiences in each subject area to other subject areas and to live in his society.

The integrating principles as specified by the document, are intended to produce among other things, a course which;

1. is relevant to student needs and experiences;
2. stresses the fundamental unity of science;
3. lays adequate foundations for subsequent specialist study, and
4. adds a cultural dimension to science education.

The course content specification contained six sections, divided equally into year one and two. In all there were seventeen units, year two containing nine units.

YEAR 1

SECTION 1 - EXPLORING SCIENCE - variety of matter.

Unit 1 - Observing the environment.

Unit 2 - Order in matter I (Living matter).

Unit 3 - Order in matter II (Non-living matter).

Unit 4 - Materials and where they come from.

SECTION 2 - INVESTIGATION OF AIR AND WATER.

Unit 5 - The nature of air and the problem of burning.

Unit 6 - Water - what is water made of?

SECTION 3 - FORCE, WORK AND ENERGY.

Unit 7 - Force and Work.

Unit 8 - Forms of energy.

YEAR 2

SECTION 4 - ACTIVITIES OF LIVING THINGS.

Unit 9 - Movement.

Unit 10 - Feeding.

Unit 11 - Reproduction, development and growth.

SECTION 5 - ANOTHER LOOK AT ENERGY.

Unit 12 - Energy : conservation and transfer.

Unit 13 - Nutrition and diet in man.

Unit 14 - Energy and chemical systems.

SECTION 6 - LIFE AND ENVIRONMENT.

Unit 15 - Health and disease.

Unit 16 - Mineral resources of the earth.

Unit 17 - Man in space.

The Newsletter (No. 1, 1970) also added that the essence of a beginning course in science is to "begin to teach students what science is and how a scientist works". To accomplish this, it continued, the course will use a method whereby all students "actually carry out the kinds of activities which scientists carry out in doing their work". This, it

stated, will involve them in beginning to acquire a "series of skills which are in turn related to the aims" outlined above. These desirable skills for students who follow the NISP were listed as follows:

- i. Observing carefully and thoroughly.
- ii. Reporting completely and accurately what is observed.
- iii. Organising information acquired by the above process.
- iv. Generalising on the basis of acquired information.
- v. Predicting as a result of these generalisations.
- vi. Designing experiment (including controls where necessary) to check these predictions.
- vii. Using models to explain phenomena where appropriate.
- viii. Continuing the process of inquiry when new data do not conform to predictions.

With regards to the procedure to be adopted by teachers, the document also specified the 'child-centred' approach which recognises that "children learn best by doing". In particular it stressed three basic strategies:

- (a) Use of discovery teaching tactics whereby children would arrive at scientific knowledge as a result of their own understanding;
- (b) The inclusion of problem solving activities, arising where possible from pupils own experiences;
- (c) The involvement of students in open-ended field or laboratory exercises.

2.1.1 NISP Curriculum Materials.

With much financial and technical support from some individuals and organisations like Comparative Educational Study and Adaptation Centre (CESAC) and Curriculum Renewal and Educational Development Overseas (CREDO) through the British Council, the major writing workshop of the NISP curriculum materials took place in September, 1970. This was followed by a critique workshop in May, 1971, held particularly for the draft course materials consisting of the Pupils Textbooks I and II, accompanied by Workbooks and Teachers Guides. By 1972, these materials were published and introduced into schools. It is worth mentioning here that, the STAN integrated science curriculum was

fully introduced directly into the classroom without the usual trial and re-trial processes that normally characterise the development of curriculum materials in order to determine their appropriateness or otherwise (Jegede, 1981 and Bajah, 1982).

The pupils textbooks I and II contained a total of 18 units. Each unit contained several activities to be performed by the pupils.

- | | |
|----------------|---|
| Book I | Unit 1 Exploring the Environment.

2 Living Things
3 Energy
4 Non-Living Things
5 Extracting substances from the world around us
6 The Nature of Air and the Problem of Burning
7 Water
8 Forces and Work
9 Energy from the Sun |
| Book II | Unit 10 Activities of Living Things - Movement

11 Activities of Living Things - Feeding
12 Activities of Living Things - Reproduction, Development
& Growth
13 More about Energy - Its conversion and Transfer
14 Nutrition and Diet in Man
15 Your Body at Work
16 Health and Disease
17 The Earth and its Resources
18 Man in Space |

The two teachers' guides contained a detailed description and discussion of what is required by the teacher for every activity and how the students are to be involved. Each unit consisted of a set of aims and objectives. These are usually followed by the plan of the unit, notes of teaching the unit, notes on the activities and materials required, practical tests and notes for the teacher.

This original curriculum for integrated science developed by STAN and which the NISP was based has been succeeded by a national core curriculum for integrated science produced by the Federal Ministry of Education. This new document, published in 1981, contains a course outline for a three year integrated science programme for the junior secondary schools. The following section examines the genesis, philosophy and the objectives of this new national core curriculum for integrated science.

2.2 GENESIS, PHILOSOPHY AND OBJECTIVES OF THE NIGERIA CORE CURRICULUM FOR INTEGRATED SCIENCE FOR THE JUNIOR SECONDARY SCHOOLS.

As a result of the Federal Government decision to adopt a National Policy on Education, which among other things, proposed a 3-3 system of secondary education, an urgent need arose to design a core content curriculum on various subjects for the two levels of secondary education (Federal Ministry of Education, 1985). The core content curriculum for the junior secondary school integrated science (Appendix G) is one of such attempts by the Federal Ministry of Education to implement the National Policy. It must be realised that before the emergence of this new core curriculum for integrated science, NISP was an exclusive curriculum project of the STAN with just approval and support from the ministry of education. The West African Examination Council (WAEC) was not even concerned with the integrated science education as it was not examined at that level.

The philosophy and objectives of the core-curriculum for integrated science were determined on consideration of the relevant portions of the National Policy on Education as they relate to science education in general and to integrated science in particular (Federal. Min. of Education, Science & Technology, 1985).

The National Policy on education (1981) states that secondary education is expected to be a :

1. Preparation for useful living within the society;
2. Preparation for higher education.

In specific terms the secondary schools should :-

- a. Provide an increasing number of primary school pupils with the opportunities for education of a higher quality, irrespective of sex, social, religious, and ethnic background;
- b. Diversify its curriculum to cater for the differences in talents, opportunities and role possessed by and open to students after their secondary school course;
- c. Equip students to live effectively in our modern age of science and technology;
- d. Raise a generation of people who can think for themselves, respect the views and feelings of others, respect the dignity of labour and appreciate those values specified under our broad national aims and live as good citizens.

With particular reference to the junior secondary school, the school will be both pre-vocational and academic. Students who, however, leave school at the junior high school stage may then go into apprenticeship system or some other scheme for out-of-school vocational training.

The integrated science core curriculum is intended to offer the junior secondary school children with science education foundation that provides relevant knowledge and appropriate scientific, intellectual and psychomotor skills to facilitate the pupils' skills in understanding their environment to the benefit of themselves and mankind in general. The course is also planned to be suitable for all pupils with a wide range of abilities, interests and aptitudes. It is also to serve as the foundation course for pupils who will eventually take up careers in science and science related disciplines at both the 'O' and 'A' levels.

The objectives and ^{integrating principles} for the new integrated science core curriculum are exactly as contained in the one reviewed earlier in this work (see pages 35 and 37).

Finally, the document describing the national core curriculum for JSS (Federal Min. of Educ., 1985), outlines the following as some of the basic assumptions underlying the design of the core content curriculum :

- i. Given the prevailing socio-economic factors in Nigeria, under the new 3-3 system of secondary education, a transition rate of 70% from primary to the secondary schools may be assumed.
- ii. A large number of school children entering the JSS may not have been exposed to the primary science core-curriculum which has been nationally adopted. Therefore the teacher should assume little, but should try to determine the entry behaviour of the child.

Necessary psychological and achievement tests should be administered to the child to determine the entry behaviour of the learner.

iii. The basic professional qualification for those who will teach this programme will be the National Certificate in Education (N.C.E.). However, during this period of transition, when teachers are likely to be in short supply, there should be proper induction and constant in-service, workshops for not only less qualified teachers but also for graduates with one science subject specialisation.

iv. Above all it is expected that the teacher of integrated science would be able to demonstrate a positive attitude to work, be willing to improvise materials, and explore his environment with children without being afraid of failure.

With the wide range of school subjects envisaged for the junior secondary school curriculum, integrated science has to be accommodated into the timetable. Teaching this programme of integrated science effectively would require sufficient time for both children and teachers. On this issue of time available for instruction, the integrated science core-curriculum document recommended that, at the very least, two double periods of 40 minutes per period be allowed to integrated science per week, (i.e. a total of 160 minutes weekly). The periods are to be so arranged as to allow for children's activities discussions and out-of-class work.

Other essential background information (support system), such as resources for instruction, including an equipment list for teaching integrated science and methods of evaluating the integrated science programme were presented as a special annexe to the core curriculum document (Federal Min. of Educ., 1985).

2.3 EVALUATION OF THE NISP.

Evaluation studies on various aspect of the Nigerian Integrated Science Project with the basic aim of finding out how successful the project has been after more than a decade years of implementation, were done by Jegede, (1981), Bajah, (1982) Bomide, (1983). In fact there is no evidence that any extensive evaluation of the whole project has been undertaken other than the individual efforts by individuals on the different aspects of the

curriculum. Areas focused on during the evaluative exercises include , readability, teachers' perception, adequacy of teaching facilities, and pupils' cognitive and affective achievement.

The results revealed that the integrated science teachers are not favourably disposed towards the project due to lack of appropriate training; the cognitive objectives achieved are below expectations but that the majority of students have developed 'positive attitudes' towards science through the project.

As observed by Ramsey, (1974), the development of curriculum materials generally for integrated science has not been closely tied to the education of teachers. This observation is very applicable to the Nigerian situation. STAN, in taking up the challenge of innovation of integrated science education world-wide and with the enthusiasm of its writers to keep up with the trend in integrated science, over-looked the very important factor of teacher training. The result was that the NISP materials were introduced into the schools to be used by teachers who have never been properly informed about or trained to teach integrated science. It is therefore not surprising to obtain the results described from the evaluation exercises. It is hopeful, however that pupils were said to gain positive attitudes to science.

It is worthwhile to conclude at this point that integrated science education had made an impact on Nigerian secondary schools. The difficulties notwithstanding, some progress had been made in developing and introducing a common core integrated science course into the junior secondary schools in the country. Evaluations had suggested that teachers did not adequately understand the nature of the integrated science curriculum nor were they prepared adequately for its interpretation and implementation. We shall turn next to the meaning of integrated science as it is portrayed in science curricula world wide before turning to the training of integrated science teachers.

CHAPTER 3.

INTEGRATED SCIENCE: Origin, Meaning and Rationale.

Before analysing the curriculum of schools and colleges, and before developing ways of interrogating teachers and tutors about their understanding of the course they were teaching, we review here the origin and meanings attributed to integrated science worldwide. Integrated science is a model of curriculum organisation, not an academic science, It is thus prone to many interpretations and meanings.

This chapter therefore attempts to review the origin, meaning and rationale for integrated science with a view to establishing if there exist any general consensus about the concept of integration in science as held by various authors writing and nations introducing such courses in or for their schools. The outcome of this review is hoped to contribute towards a theoretical base for developing a tool to examine:

- (i) the nature of integration portrayed in the Nigerian Junior Secondary School core-curriculum for integrated science and in the curricula for integrated science teacher education in Nigeria;
- (ii) opinions held about the meaning of integration in science by integrated science teacher educators, student-teachers and secondary school integrated science practising teachers; and
- (iii) what issues are to be considered relevant for inclusion in the curriculum for the education of teachers of integrated science as perceived by the integrated science teacher educators in Nigeria.

3.1 GENESIS AND SPREAD OF INTEGRATED SCIENCE WORLD WIDE

The post-Sputnik curriculum reforms initiated in the United States of America in the late 1950s, followed by Europe and many other parts of the world in the 1960s saw the emergence of many progressive science curricula. The reforms were initiated by the Physical Science Study Committee (PSSC), Chemical Bond Approach (CBA), and CHEM Study - all in the United States of America; and the Nuffield Projects in the United Kingdom.

These curriculum reform projects shifted emphasis in science teaching from the mere acquisition of factual knowledge to an emphasis on total personal development and active involvement of the individual pupils. This change in the methods of teaching and learning coupled with the emphasis on how science is used led to the foundation of what became known as integrated science. What existed prior to this, particularly in the United States of America, was the 'memorisation of definitions of formulae - dominated physics, chemistry and biology teaching that degenerated to drawing labelled diagrams only' (Lewis, 1979).

The major aims of these curriculum reform projects according to Lewis, (1979) was, " to give the pupils the opportunity to be 'a scientist - for - the - day', to experience how scientists look for evidence, how they test hypotheses, how they look for patterns in the phenomena around..."

However by the mid 1960s these immediate post-sputnik curricula were felt not to be fully adequate for purposes of general education. For instance, the Association for Science Education (ASE) in its consultative document (ASE, 1979) accuses the Nuffield Science Teaching Project's secondary (O- Level) curriculum of that period of concentrating "its main energy on the education of the future scientist". This was because the O' level projects were not integrated although they were practically oriented. As well as this inadequacy, Lewis (1979) further reported that some of these projects had themselves "come to realise that searching for fundamental laws did not meet all needs" of pupils; rather what was required was a broad-base curriculum in science which would provide all

pupils with the opportunity to learn about the central concepts of science; practice the processes the scientists adopt in their work; learn about how science affect their lives and how their decisions as citizens can influence the course of science, among others. According to Jegede, (1981), the writings of Conant and Bagrit, among others, did much in advocating for the popularisation of science through the education system so that all and sundry, from house wife through the business manager to political decision makers will have a good understanding of what science is, how it affects their lives, and how scientists operate.

By the mid-1960s, it was clear that a number of these science reform movements have "science for all" as a major goal. In addition the recognition of the apparent intra and interdisciplinary integration in major scientific theories like atomic physics, thermodynamics, chemical bond theory, genetics, evolution etc., which had developed early in the century, requires the learning of a lot of scientific concepts across several science disciplines. Consequently, UNESCO brought together all these various efforts by convening a planning meeting in Paris in March 1969 to advise on its programme of integrated science teaching as provided for under programme resolution 2.211 adopted by the General Conference at its fifteenth session (Richmond, 1971). The meeting used as its basis, the aspiration for integrated science teaching at the primary and junior secondary levels set forth in the CIES report of the Verna Congress on integrated science teaching and in the final Report of the Regional Workshop on UNESCO/UNICEF Assisted Projects in Science Education in Asia, Bangkok, in November, 1968.

The meeting noted that all the science curriculum reforms projects (which includes Science 5/13; African Primary Science Project; The Elementary Science Study; The Science Curriculum Improvement Study; *Instituto Brasileiro de Educacao Ciencia e Cultura* ; The Minnesota Mathematics and Science Teaching Project; The National Council for Educational Research and Training; The American Association for the Advancement of Science; Science-A Process Approach; The South-East Asia Ministers of Education Council; The Swedish International Development Authority; The National Science Foundation and the Educational Development Centre), have provided integrated science

teaching materials in which the concepts of science are presented through a unified approach. The meeting also recommended that these projects and others should provide expertise and knowledge which would be the starting point for integrated science programmes.

In Britain, between 1969 and 1973, the Nuffield Foundation, the Scottish Education Department and the Schools Council, often co-operating with one another, produced and launched four integrated science curricula aimed at meeting the general education requirements (Chisman & Lucas, 1973). These curricula were :-

- i. The "Scottish Integrated Science Project" (Scottish Education Dept. 1969)
- ii. "Nuffield Combined Science Project" (Nuffield Foundation, 1970 & 1971)
- iii. "Science 5/13", and "Schools Council Integrated Science Project: Patterns" (Schools Council, 1972-74).

These curricula and many similar ones that started to emerge in the United States and elsewhere at about the same period were referred to as "Integrated Science" curricula, not only because they sought to meet the requirements for general education, but also because they drew their subjects matter from various sciences and other disciplines (interdisciplinarity). These curricula displayed, albeit to varying degrees, conscious efforts to de-emphasise the boundaries between different disciplines in the organisation and presentation of instructional materials. In the United States, the curricula produced by the Science Curriculum Improvement Study (SCIS), the Conceptually Oriented Programme in Elementary Science (COPES), Science-A Process Approach (SAPA), were among many others in the country which fell into the integrated science category, but in very different ways depending on the integration model adopted.

By the late 1960s to the early 1970s many developing nations had got wind of the movement in the developed countries towards an integrated approach to science teaching in the primary and secondary schools. Hence, between 1968 and 1971, the Science Teachers Association of Nigeria (STAN) had developed and published a blue-print for an integrated science curriculum for the first two years of Nigerian secondary schools (STAN, 1970).

This STAN curriculum as well as the texts for the course published later in 1971 have been reported by Jegede, 1980; Abah, 1991 and this study, to be closely modelled after the Scottish Integrated Science Project, though the contents were carefully adapted to suit the Nigerian environment and circumstances.

Adapted forms of the Scottish Integrated Science Project were also introduced into secondary schools in Botswana, Hong^g Kong and the Caribbean among other countries while modified forms of SAPA were introduced into the primary schools in many African countries including Ghana and Nigeria (Abah, 1991).

The rate of dissemination of the philosophies and models of integrated science curricula around the world was greatly enhanced by the intervention of the UNESCO in the integrated science movement. In 1968, UNESCO organised the first international conference on integrated science in Droujba (near Verna) Bulgaria, during which scholars from different parts of the world exchanged ideas about the philosophy and rationale of integrated science teaching. Further UNESCO conferences on integrated science teaching have been held in Maryland, Nijmegen, and Canberra in 1973, 1978 and 1988 respectively. In addition to organising conferences, the UNESCO has since 1971, published a series of six volumes of resource books titled "New Trends in Integrated Science Teaching" which not only articulated the philosophy and curricula trends in the subject world wide, but also threw much light on vital aspects of curriculum development such as "teacher education" and "evaluation" in integrated science teaching.

Sequel to this role played by UNESCO to boost integrated science education world wide, the number of new integrated science projects around the world has risen sharply. About a decade after the UNESCO first international conference on integrated science, Haggis and Adey (1979) identified and collected data on at least 130 courses and projects on integrated science being run in the world. As at now Chisman (1990) reported that in a survey organised by the International Council of Association for Science Education (ICASE) in 1988, about 40 countries provided data about integrated science courses which they operated. There is therefore no doubt that integrated science has been established in many parts of the world and maintaining an upward trend in its growth and spread to date.

3.2 THE MEANING OF INTEGRATED SCIENCE.

The difficulties inherent in the study of integrated science become apparent when attempts are made to define the term. This is not only a problem to the student of integrated science but also to their teachers, the teacher educators, curriculum developers and many others who are involved with or have concern for science education. There is much that remains confounding about the real meaning of integrated science in relation to its implementation. An attempt is made in this section to review the efforts made by various writers to throw light on the meaning of integrated science.

In reviewing the meaning of, and argument for integrated science, Brown (1977) did mention that the meaning of integration and indeed the value of the integrated approach have not always been made explicit in spite of the fact that many integrated science curricula have been developed in recent years throughout the world. Earlier to Brown's observation, Chapman (1976) had commented on another dimension of the difficulties with the definition of integrated science when he said:

"a major problem with the whole notion is to decide who has the authority to define it. Is it a philosopher, sociologist of knowledge, a science teacher, a non-science teacher, a lay member of the public, a pupil or the ASE?"

In this attempt to place in perspective the many views expressed about the nature of integrated science, the literature reveals considerable efforts by writers to throw light on the meaning of integrated science. While some sources attempted a definition of integrated science in one to a few sentences, others preferred a descriptive approach which allows more room for dwelling on the philosophical, organizational, and social perspectives of integration. As Bajah (1983) aptly noted, straight forward definitions of integrated science are scantily documented; most writers prefer the descriptive approach whereby the qualities and advantages of integrated science are more freely discussed.

The Verna Congress on the integrated science teaching accepted the definition of integrated science as the "joining together of several subjects into a single course in which

the concepts of science are presented through a unified approach." Clearly by the standard of this definition, there can exist a multiple of approaches by which this unified approach can be attempted, and courses vastly different both in character and aims can exist within this definition.

Rutherford and Gardner (1971), Yoloye (1971), and Jacobson (1971) have looked at integrated science broadly as a subject arising from the learners environment and ways of learning about the natural world and science as a unified subject.

In terms of curriculum development, Showalter (1975) asserted that:

"Today, the label 'integrated science' may be applied generally to any curriculum development effort in which two or more previously separate science subjects are combined".

Later in 1979, Showalter defined integrated science in terms of its social relevance when he wrote:

"Teaching science as unity is assumed to mean that all science as human endeavour is taken as the source of educational objectives and learning activities, and that the traditional boundaries among the separate sciences are minimised considerably for these purpose."

Brown (1974), considered integrated science as a science curriculum 'presented as a unified discipline rather than the three separate disciplines that have characterised secondary school science.'

Chisman (1973), in his definition of integrated science, indicated three main approaches to its teaching:

- i. in which concepts and principles of science are presented in such away as to express the fundamental unity of scientific thought;
- ii. which emphasises the processes and methodology of the scientific outlook;
- iii. which embody a scientific study of the environment and technology requirement of everyday life.

These three points are similar to those proposed by D'Arbon, cited in Cohen (1977) who attempted to develop an all embracing definition of the term 'Integration' as applied to integrated science. D'Arbon was reported to have synthesised the responses to a questionnaire administered to a number of well known writers in the field of integrated science and produced the following comprehensive definition:



"Integration", when applied to science courses, means that the course is devised and presented in such a way that the students gain the concept of the fundamental unity of science; the commonality of approach to problems of a scientific nature; and are helped to gain an understanding of the role and function of science in their every day life.

An integrated science course eliminates the repetition of subject matter from the various sciences and does not recognise the traditional subject boundaries when presenting topics or themes. Integrating principles are intended to produce a course which:

- i. is relevant to student needs and experiences;
- ii. stresses the fundamental unity of science;
- iii. adds a cultural dimension to science education.

It is easily noticeable that D'Arbon's definition encompasses all aspects of those cited above, but the point in his definition, whether deliberate or not, are stated in terms of students outcomes. Unfortunately, these desired student behaviours are somewhat diffuse and appear to defy measurement. Furthermore, his statement that "...integrating principles are intended to produce a course which is relevant to the student needs and experiences" raises more questions as to who decides what these needs or experiences are; is it the students themselves or the teachers, or the curriculum developers etc.?. There is also the use of this phrase, "...the fundamental unity of science" in the definition which also appear in several other definitions proffered by other writers. The use of this article "the" in the phrase gives the impression or assumes that there is already an existing fundamental unity in science to which pupils can be exposed to. If this is not the case, then the use of the article "a" in place of "the" would be better in removing such a strong assumption.

Brown (1977) in a review of the meanings of integrated science identified four groups of meanings of integration:

- i. as the unity of all knowledge.
- ii. as the conceptual unity of the sciences.
- iii. as a unified process of scientific enquiry.
- iv. as interdisciplinary study.

Brown's grouping was preceded by similar grouping made by Rutherford and Gardner (1971) when they noted that for a course to be considered truly integrated, it is necessary

that " concepts of science are presented through a unified approach", and they went on to suggest and discuss four ways in which this could be done, namely:

- i. the conceptual schemes approach.
- ii. the enquiry approach.
- iii. the relevance approach.
- iv. the process approach.

Considering the contents of Brown's grouping on one hand and those of Rutherford and Gardner on the other hand suggests that groups (i), (ii) & (iv) of Rutherford & Gardner can be subsumed under Brown's groups (ii) and (iii) respectively. Thus, it can be seen that Brown's grouping is more broad and embraces all of Rutherford and Gardner's except for the "relevance" approach which is absent in Brown's grouping. Since 'relevance' is an important facet of integrated science as noted earlier in this section, and else where in the literature, it becomes necessary to add this group to Brown's four groups of meanings of "integration" as it applies to integrated science, viz.:

- i. as the unity of all knowledge;
- ii. as the conceptual unity of science;
- iii. as a unified process of scientific enquiry;
- iv. as interdisciplinary study;
- v. as the social relevance of science.

For the purpose of making further clarification on the meaning of integrated science, these five broad groups of the meaning of integration are discussed briefly below.

3.2.1 The unity of all knowledge.

The view of integration as the unity of all knowledge is one which in the words of Brown (1977) "implies the greatest scope." It is the holistic view of knowledge as being essentially one and undivided. This view according to Rutherford and Gardner (1971)

stems from an implicit assumption that "the universe itself is somehow unified." Such assumption, they maintained, goes back to the Aristotelian belief that "all of man's experience and concerns are linked into a single integrated system." In a similar vein, Blum (1973) notes that many reputed scientists of history including Einstein "believed in the unity of the universe and tried to discover the unifying laws of nature." It is quite interesting to note that the pursuit of such discoveries by most early scientists (who might be regarded as 'generalists' by today's standards) delved deeply into various aspect of scientific research without restrictions. Thus, it was common to find one scientist deeply involved in research in areas that might today be categorised into astronomy, physics, chemistry, biological science, among others. Their concern then was on solving a particular problem and discovering one thing or the other about the universe and they were not restricted by any artificial disciplinary boundaries. Robert Boyle (1627-1691) and Alexander Humbolt (1769-1859) are good examples of such early scientists (Chisman, 1990).

Hence, the view of integration as the unity of all knowledge would, in fairly restricted sense, means the organisation of all relevant scientific knowledge (irrespective of discipline boundaries) towards providing pupils an understanding of a particular phenomenon, or helping them solve a particular problem relevant to the educational context. In the most general sense, it would mean the organisation of not only scientific knowledge but also other forms of knowledge for the above stated purposes. However Showalter (1979) cautions that integration across "realms of meaning" as implied in the general sense approach can cause problems. For instance he noted that "Darwinism, as with science, must be subject to refutation" while "Genesis, which belongs to the realm of synoptics is not", and hence trying to integrate these two realms could lead to disharmony. Even in the more restricted sense of unity of all scientific knowledge, reservations were expressed by Schwab (1964) when he wrote:

The doctrine of unity of science, which insists on the unification of all knowledge, is either dogma or hope but not a fact. There are no data from which to conclude decisively that eventually all the disciplines will become or should become one.

The lack of unifying principles around which all knowledge could be organised also continues to pose problems. Noting the elusive nature of how the integration of "all knowledge" could be practically achieved, Brown (1977) concluded that curricula integrated in the sense of the unity of all knowledge are very seldom found. However Pring (1976) is of the view that the use of "themes", "Topics" and "Ideas" are capable of providing the kind of integrating element in a curriculum. The thematic approach is adopted in the organisation of the Nigerian integrated science core curriculum for the junior secondary schools, but to what extent the core curriculum reflects this approach to integration, is analysed in Chapter 6, section 6.1.

3.2.2 The conceptual unity of the sciences

The view of "integration" in terms of the conceptual unity of the sciences arose from the general belief by scientists and philosophers of science that in its bid to understand and explain natural phenomena in the universe, science has produced knowledge that is discernible in the form of broad conceptualisations. Such broad conceptualisations often referred to as the "big ideas" or "conceptual schemes" or "major concepts" have been constructed by scientists on the basis of evidence from discoveries in various scientific disciplines. These "big ideas" therefore represent a distillation of the intellectual achievements of science which bear relevance across different scientific disciplines. Their significance for science education is evident in the following except from Shamos (1971):

Granted the premise that some understanding of science is important for every one, the question then follows, what is the best way to help students attain a level of understanding and appreciation of the scientific enterprise that will serve them through their adult lives? Our answer is to focus their attention on the 'great ideas' in science, the broad, inclusive conceptual schemes in terms of which we seek to account for the familiar facts of nature. Such unifying ideas... are the main goals of science and we believe should form the core of a science curriculum. They represent the pinnacle of explanation in science and must surely be classed among man's greatest intellectual achievement.

Because of their survival value (which is by far more than that of the small concepts and facts subsumed under them), and the fact that they unify ideas from various science disciplines in a way that is acceptable to science, these conceptual schemes hold great appeal for the ideals of conceptual integration of the sort desired in integrated science. The publication of the National Science Teachers' Association (1964) and Shamos (1971) helped much to stress and focus the attention of science educators on the importance of conceptual schemes in science curriculum development. Today, a considerable number of these conceptual schemes and major concepts are recognised and incorporated in many science curricula around the world. For example, the Wisconsin Department of Public Instruction (Kahl, 1971) recommended six conceptual schemes for use as a basis for the organisation of science curricula. These schemes, each of which was assigned a one word identifier to be used in referring to the total idea, were presented as follows:-

DIVERSITY...The vast number of natural phenomena which can be observed display a wide variety of similarities and differences.

CHANGE...Our environment, living and non-living, microscopic and macroscopic, is constantly undergoing change.

CONTINUITY...There is constancy in cause-and-effect relationships which precludes any abrupt reversal in natural phenomena.

INTERACTION...The interaction of matter in an environment and the resulting exchange of energy determine the nature of the environment.

ORGANISATION...Systematic relationship exist in natural phenomena. Systems within systems comprise the universe.

LIMITATION...Natural phenomena are limited by the fundamental nature of matter and energy. There is an overall tendency towards random distribution of energy and a corresponding tendency towards equilibrium in an environment.

An outline of how these conceptual schemes can be seen to cut across the biological, physical and earth sciences was also provided.

Shamos (1971) also reported that the "Conceptually Oriented Programme in Elementary Science" (COPES), was organised around five conceptual schemes, namely:

- i. The structural unit of the universe;

- ii. Interaction and change;
- iii. The conservation of energy;
- iv. The degradation of energy;
- v. The statistical view of nature.

The Schools Council Integrated Science Project is another good example of a curriculum organised around the conceptual schemes of science. In that curriculum the following three conceptual schemes serve as the fulcrum:-

- i. Building Blocks;
- ii. Interactions; and
- iii. Energy.

There is no doubt that the conceptual schemes approach is a very promising avenue for integrating the facts and concepts of the sciences. It becomes particularly relevant when such concepts or conceptual schemes are appropriate to the developmental level of the pupils, as some of them can be quite abstract requiring a high cognitive level and therefore can be taxing for the integrated science target pupils.

3.2.3 A unified process of scientific enquiry

This approach emphasises the methodological distinctions and similarities among the sciences. The idea of integrating sciences on the basis of a unified process of enquiry arose from the assumption that scientists, irrespective of their special disciplines, do engage in certain processes or activities in the course of their work. For example, they are known to engage in such activities as observing, classifying, inferring, predicting, measuring, communicating, interpreting data, making operational definitions, formulating questions and hypotheses, experimenting and formulating models, among others. The belief is that if children are given the opportunity to practice these activities then they would be behaving in a manner characteristic of the scientists and hence would be learning science in an

integrated form through its processes. Moreover the medium of the contents with which they interact to practice these processes could be selected from a wide range of sources (biological, chemical, physical, etc.) to broaden their experiences and further the goal of integration. Supporting the learning of the above processes through school science teaching, the American Association for the Advancement of Science (1971) had this to say:

If scientists have learned to gain in these ways, surely the elementary forms of what they do can begin to be learned in the early grades. This line of reasoning does not imply the purpose of making every one a scientist. Instead it puts forward the idea that understanding science depends upon being able to look upon and deal with the world in the ways that the scientists does.

Hence the AAAS curriculum project "Science - A Process Approach (SAPA)" was based strictly on this philosophy.

Swanton (1990) identified three British science curricula as "process-led" in the light of their heavy dependence on the process approach. These are "Nuffield Science 11-13" (The Nuffield-Chelsea Curriculum Trust, 1986); "Warwick Process Science" (Screen, 1987); "Science in Process" (Inner London Education Authority, 1987). A number of other integrated science curricula preferred to maintain a middle course. For example, Brown (1977) reports that the Schools Council Integrated Science Project "in addition to perceiving integration in the conceptual structure of science, was fundamentally concerned with a particular process scheme (related to Gagne's 1970 learning hierarchies and model) of searching for and using patterns to solve problems (see details of Curriculum project analysed in Chapter 4). The Scottish Integrated science project (Scottish Education Department, 1969) and the Nigerian Integrated Science Project (STAN, 1970) also indicated significant effort towards the process approach to integration in addition to other approaches.

It is worth noting here that although these processes often referred to as 'Science Processes' are not exclusive to science, emphasis is being laid on in science because of the way scientists make conscious and deliberate use of the processes in their attempt to understand the world. But it is doubtful if other non-science endeavours which employ the use of these processes are any more than common sense and if ever they use all of the

processes as science in most cases does. These processes, taken as a set, is what distinguish science from other disciplines.

3.2.4 An interdisciplinary study.

In defining integrated science as an interdisciplinary study, it is seen as a collaborative venture between disciplines. It makes use of subject matter from various scientific and other disciplines. Abah (1991) sees this view of integration as the most encompassing because whether one is talking of integration from the point of view of unity of all knowledge, conceptual unity of the sciences, process of enquiry or social relevance, the involvement of subject matter from various disciplines is inevitable if full integration is to be a reality.

Of course integration of subject matter within one discipline has also been in practice and this is what Jevons (1969) refers to as "internal integration". Common examples of such subject-centred, scientist-oriented curricula like the Harvard Project Physics, BSCS, CBA and the Nuffield Projects during their early stages of development. However most recent 'integrated science' programmes, especially those meant to substitute the discredited "general science" are almost invariably interdisciplinary in design.

The integrated science programmes around the world however, differ in the range of disciplines from which they draw their subject matter which Blum (1973) calls the "Scope" of integration. Blum's analysis reveals, for instance, that the Schools Council Integrated Science Project incorporates subject matter which spans biology, chemistry, physics, mathematics, agriculture, health & nutrition and socio-cultural issues. He also showed that the Nuffield Combined Science has contents spanning biology, chemistry and physics in the main, with some aspects of applied and technological matters.

Blum however drew attention to the fact that not always is a maximal scope of integration the best, although where young children are to investigate their own environment freely, such wide scope may hold the best premise. Jevons (1969) also

cautions that " limitations of time, of human mental abilities mean that only a limited number of integration can be achieved in any course." As to the strategy for achieving a successful interdisciplinary integration, Blum's (1973) suggestion is "to decide first, what educational aims should be reached and then choose, together with the subject matter specialists, the best way to achieve this aim."

3.2.5 The social relevance of science.

One of the main reasons for the introduction of integrated science in schools was to make science relevant to the environment, lives and society of the pupils. It is from this point of view that integrated science is seen to mean science is taught to reflect its social relevance.

In promoting this aspect of the meaning of integrated science, Rutherford and Gardner (1971) saw the social relevance of science as constituting two major components, namely "environmental science" and "applied science", both of which centre on the utility of science. Hence they saw that the inclusion of such issues as the location of nuclear reactors; the role of science and technology in causing and alleviating the pollution of the environment; the propriety of organ transplant; controlling the population; problems of nutrition and health; and utilisation of computer technology as components of integrated science course would "necessarily involve students in exploring ideas from the realms of physics, chemistry, biology, meteorology, geology and other sciences as well as from social ethics."

Lewis (1979) expresses strongly the need for integrated science teaching to focus more on the relevance of science to society. He buttresses his argument by reference to a participant at the 1978 Nijmegen conference who persistently urged that " man must be at the centre of our teaching" and Einstein's appeal to scientists that 'concern for man himself and his fate must always form the chief interest of all technical endeavours.' Lewis then provided a number of themes which he stated enjoyed unanimous approval by the working

group at the Nijmegen conference as appropriate for use in teaching science in a socially relevant manner. These include: Energy- its conservation and sourcing and the dangers of nuclear energy; resources of land and water; environment consequent of mining; population; health and medicine; food, nutrition and agriculture; industry; data handling and communication; history of science and technology; poverty; and the quality of life.

Chisman (1990) emphasised the need for integrated science teaching in the 1990s to focus on topics of social relevance which he identified as presented in Figure 2 below, and recommended an exploration of their interrelationships.

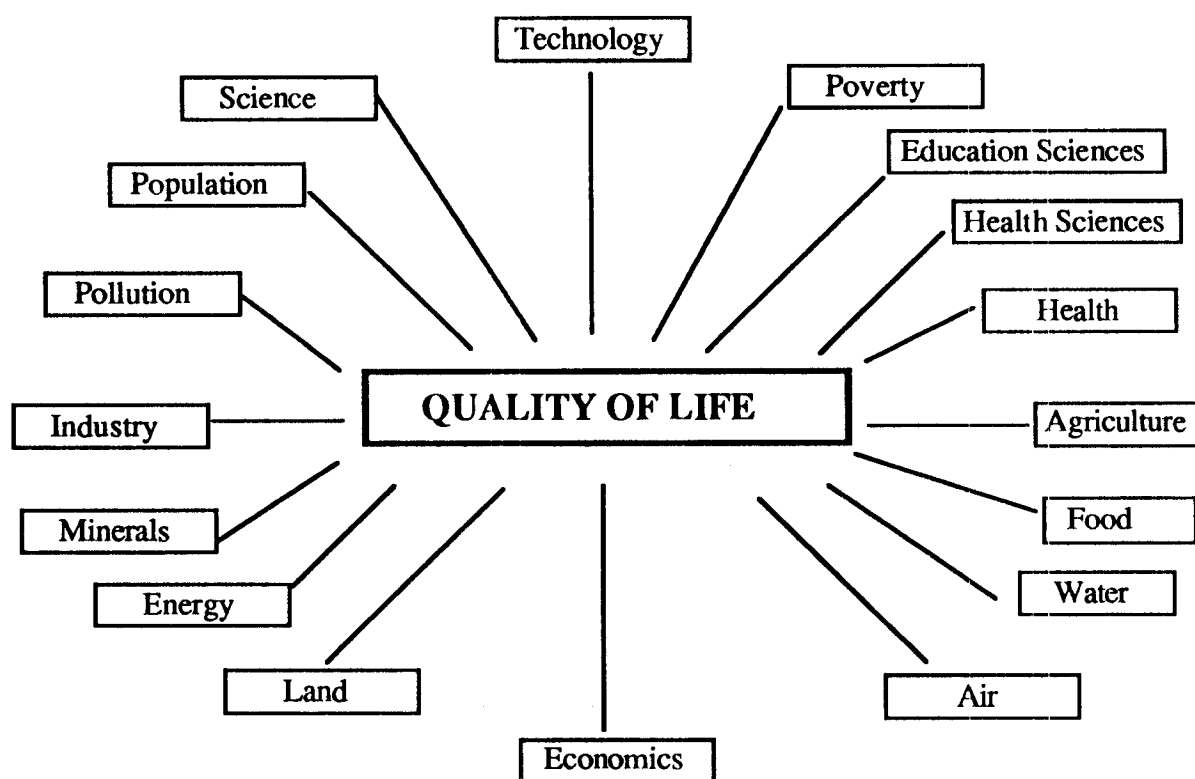


Figure. 3.1 Topics of social relevance for integrated science teaching.
(Chisman, 1990)

Chisman, however, called for debates among teachers and educators on the "parameters" (scope) of integrated science teaching particularly the extent to which it can go into areas such as 'technology', 'economics' and 'ethical factors'.

In view of the importance attached to social relevance in integrated science teaching, most integrated science curricula have made provisions for it. Notable examples include the Schools Council Integrated Science Project in England has "a significant social component"

(Haggis and Adey, 1979). The Nigerian Core-Curriculum for Integrated Science also calls for relating science to the life and world of the child and it contains socially relevant themes such as "You and your home", and "Saving your energy" among others.

3.2.6 Summary and Conclusion.

From the foregoing exposition and discussion on the definitions and range of meanings of integrated science, certain points come up clearly and strongly by which the researcher feels that integrated science might well be defined. Thus in the light of this, the meaning of integrated science can be summarised as a science course which:

- i. makes use of subject matter from various disciplines;
- ii. De-emphasises the boundaries between different disciplines in the organisation and presentation of subject matter;
- iii. Consciously seeks to blend the subject matter from various disciplines by organising them under common themes/conceptual schemes/major concepts and science processes;
- iv. Provides opportunity for practising the various science process skills including scientific approaches to problem solving;
- v. Promotes the application of scientific knowledge and skills to solve human problems;
- vi. Relates science to the environment and culture of the learner;
- vii. makes use of relevant psychological theories of learning in the organisation and presentation of subject matter; and
- viii. Provides adequate science foundation in pupils for further studies in the sciences.

However, the main problems confronting educationists, curriculum developers and teachers now is how best to translate these precepts into reality. In the attempt to do this, it appears that different people from different countries show considerable differences in the amount of emphasis placed on various aspects of the meaning and purpose of integration. This is not altogether unexpected, because integrated science, due to its strong societal and

environmental fervour is bound to vary as such in order to be contextually relevant. Little wonder then that Hayward (1973) described integrated science as the "untidy Field". It is clear from here that there is no sharply delineated classification of knowledge that we can term integrated science, instead there exists a loose amalgam of meanings and definitions all of which share as a unifying characteristics "a common distaste for an organisation of science in to discrete, unconnected subject disciplines of the traditional type."(Brown, 1977).

In general, therefore, most of the definitions and range of meanings given to integrated science agree basically that integrated science is a unified course presented to pupils up to the early secondary school years serving as a good foundation for scientific literacy, personal growth, social relevance and general education.

3.3 RATIONALE FOR INTEGRATED SCIENCE

Just as there are a variety of definitions of integrated science, there are as many rationales or justifications advanced in support of integrated science curricula. Among the many arguments in favour of a unified approach to science teaching, curriculum developers tend to favour those which relate to the meanings of integrated science reviewed above. Basically the rationales have been based on "empirical evidence on value judgements and substantial logical arguments or on myths" (Brown, 1977).

In providing justification for teaching unified science, the Federation for Unified Science Education (Kirby, 1980) advanced the reasons that:

- i. the natural phenomena have no inherent properties that make them the exclusive property of biology, chemistry, physics etc.;
- ii. disciplines are intellectual conveniences that facilitate specialised study;
- iii. if scientific literacy is to be a reality, education should be generalised rather than specialised; and

iv. processes and scientific enquiry are basic to all disciplines.

Similarly, Jegede (1980), Kirby (1980) in their attempts to review from literature the rationale for integrated science, identified three broad categories under which the rationales could be grouped. These are:

- i. The unified nature of the world and the unity of knowledge.
- ii. The nature of science.
- iii. Science and society.

A general consideration of the arguments or rationales advanced in support of the teaching of integrated science in schools appear to fall within the following categories:-

- i. The unified nature of the world and scientific knowledge.
- ii. Methodology and concepts in science.
- iii. Psychological and pedagogical factors.
- iv. Science and society.

These categories are examined briefly.

3.3.1 The unified nature of the world and scientific knowledge.

Rutherford and Gardner (1971) in writing on this aspect claimed that as a matter of faith rather than as conclusion on evidence, most scientists and, indeed, most individuals believe that in some sense the natural world is of one piece. They raised the fundamental premise that science is unified in substance and contents, and that there exist " a finite set of logically related laws and theories... to explain natural phenomena." Showalter (1979) also believe in a unified natural world when John Murr's philosophical statement of 'when you reach out into the world and grab hold of something you find that it is hitched to everything else' is interpreted to mean that we live in one world and that things and events in it are manifestations of the same natural order and system.

Perhaps this could be one of the reasons why earlier scientists and philosophers like Aristotle, Einstein and Socrates believed very strongly that the universe is a united entity and proceeded to try to discover the laws that unify nature (Blum, 1973). These foregoing arguments, somehow Aristotelian in their flavour, may be highly debatable and unlikely to be persuasive to those who are not involved in integrated science. This is because the arguments are not based on any scientifically empirical evidence but rather on hope and faith.

Perhaps the more powerful and utilitarian argument along this line is one which believes that disciplines are intellectual conveniences that facilitate specialised study. Many writers (Brown, 1974; Lewis, 1979; Booth, 1978; Showalter, 1979; Black, 1986) are therefore of the view that whatever boundaries we have created around subjects being studied are somewhat quite artificial. Evidence abounds in the fact that one of the characteristics of modern science has been the emergence of areas of importance which arise from the overlap of traditional disciplines, e.g. biochemistry, biophysics, physical chemistry etc. These new disciplines require not only facility in areas of specialisation but also ability to communicate, to link with the more established disciplines. Blum further substantiated this argument when he wrote:

"... most research is done by teams which are more often than not made up of scientists with special knowledge and skills in their respective narrow fields, but who can communicate and interact creatively with members of other disciplines. They must be able to see their limitations and how these can be overcome by creating new connections between different subjects and methods. Integrated science teaching can help to educate students to look at field of study not only from within but also from the viewpoint of links between disciplines." (Blum, 1973).

3.3.2 Methodological and Conceptual Arguments

The methodology and concepts in science are other focal points for arguments in support of integrated science. Kirby, (1980); Jegede, (1980) referred to this as the nature of science related ^{to} processes, concepts and values that are unique, but general to other aspects of science.

Regarding the processes and scientific enquiry, AAAS (1970), Jacobson, (1971) Black, (1986) believe that they are all basic to all science disciplines and that some of the approaches used in the sciences are among the powerful intellectual tools available to us and the ability to use some of these approaches in our daily life should be part of our cultural legacy. Jacobson feels that the building of a scientific world view, the organisation of a conceptual structure of science, and the development of the ability to use some of the processes of science are important dimensions of science as culture.

In support of this argument Black, (1986) explains that, although the separate disciplines of science have clearly defined contents, they are not independent, but that on one view, physics covers the whole of nature, chemistry is nested within it using its principles in order to study a narrower range of more complex systems, while biology is nested within both, using principles of the physical sciences to study problems of even narrower scope and greater complexity. He illustrated his view in the following diagram (Fig. 3.2).

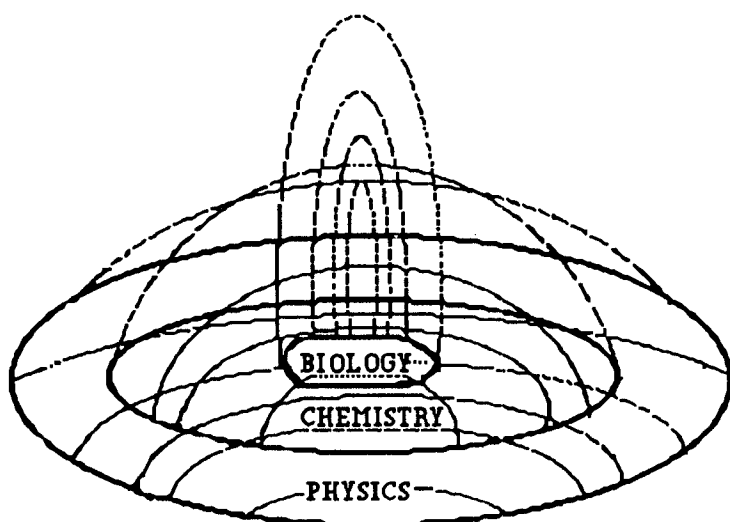


Figure 3.2: The texture of the three sciences - a pictorial metaphor.

(Black, 1986)

In the diagram, the full thickened circles indicate the inclusive nesting and on their own imply dominance of physics. The thin broken lines indicate the possibility of another dimension, which could be of levels of complexity, or of relevance to the human beings who generate this knowledge. Black then drew attention to the point that accepting that this

diagram has legitimacy, it gives a possibility of arguing that in respect of processes and concepts, science is a unified activity. For processes, it is true that at an elementary and vague level of description, all the sciences share the need for measurement, observation, inductive generalisation, prediction from models and so on. He also added that from the above concept of 'seduction by reductionism', a view which claims that physics will explain the whole of chemistry, and these together will explain biology; it follows from that view that there is a principle of unity for science which can be the basis for an integrated curriculum and that integrated science should build on physics as the central model.

The pictorial metaphor of the texture of the three sciences, depicts not only their relationship but also describes an element of a philosophical basis for integrated science as unity.

The AAAS analysed the method used by scientists and identified a number of processes; eight basic and five integrated. These scientific processes are the foundation of one of the largest curriculum development projects in the USA; Science - A Process Approach (SAPA). This project designed for children from 5-12 years has as its major intent "...to facilitate the development of scientific processes which underlie the discovery and continuing development of scientific knowledge." (AAAS, 1970).

In the same vein the Scottish Integrated science course, and other process-oriented curricula (see section 3.2.3) state that their intent is to show students how scientists work, the method they use and the processes by which they obtain their conclusions. Hence deliberate attempts have been and are still being made to structure curriculum programmes around the methodology of science. At the heart of these science process-oriented curricula, is the assumption that there is a methodology that is common to all sciences. This view has long been propagated by adherents to the scientific method. However even a superficial examination reveals that rarely does science progress by an all-powerful process. In fact more often than not it stumbles along with the element of genius, luck, diligence and more than a fair share of mistakes.

Many writers claim that the different sciences have evolved their own characteristic mode of enquiry. For example, this view is made explicit in Jacobson's writing when he wrote "...

since there are different modes of enquiry in different sciences, students should have experiences with as many as these different modes of enquiry as possible." (Jacobson, 1971). Schwab, (1964) had earlier made a detailed study of the procedures and methods used by the different sciences. He pointed out that the separate disciplines have different goals, in terms of their search for knowledge, and these in turn dictate different mode of enquiry. There has therefore been an old and prolonged controversy regarding the methods of scientific enquiry. Some part of the controversy borders on the question of whether there is the scientific method and do all sciences use one or many similar methods (Poincare, 1958; Toulmin, 1967; Popper, 1969; Tawney, 1974).

However the point should be made that the nature of the various sciences do not remain static but change. It is therefore likely (presumably) that these sciences will evolve and their methodologies will become more characteristic of the sciences.

Many writers have also expressed their views supporting the fact that although there is no single scientific method of investigation, there is a commonality in methods that exist in the sciences which invariably gives science its distinctive niche. For example, in a lecture delivered on "Teaching" at the university of Cambridge as far back as 1880, and reported in Booth,(1978), Sir Joshua Fitch said that after all, the main reasons for teaching some branches of science is to be found in considering the sort of processes by which the truth of such sciences are investigated and the faculties of mind which are exercised in the course of physical investigations. He believed that a student studying any branch of natural history or science must learn to observe carefully to use his eyes and to know the differences between facts which are abnormal and facts which are typical. Then the student should come into contact with realities, must handle objects, must experiment, question matter closely, wait and watch, invent new forms of tests until he^{she} is quite sure that he^{she} has hold of the true answer. His^{her} theory or final generalisation, therefore, when it comes must have been actually suggested by the facts.

Rutherford and Gardner (1971) in supporting the above ideas stated that those scientists and educators who must strongly advocate integrated science teaching often share

the view and believe, furthermore, that those processes are essentially the same in all of the natural sciences. They said:

"There is general agreement in the scientific community sometime indicated by scientific method, on such matters as the appropriate language for stating scientific problems, how one collects data and analyses it, the correct application of logic, the use of theories and models, and the need for verification and for critical appraisal by colleagues. Many educators feel that these and other methodological attributes of modern science are of greater significance than the particular body of facts, laws and theories that comprise the findings of the separate sciences at a particular time."

Perhaps one of the most unambiguous and very powerful support for the rationale of teaching integrated science from the stand point of the nature of science processes in modern days has been that of Showalter who said that when we talk of variables we have entered the process dimension of science which involve the generalisation of new knowledge. He contended that, taken as a set, the processes of science distinguish science from other ways of knowing. Some of the processes in addition to controlling variables, as listed by him, are inferring, observing, questioning, measuring, hypothesising, interpreting data etc. He also argued that these processes are common but exclusive to all science and this forms one argument for the nature of science.

Showalter reiterated that the universality of the processes of science is further emphasised when we realised that any one of the processes could be 'done' by any person at his or her own level of sophistication. Thus any one can generate new knowledge for himself in science and it seemed logical for people to be educated to use these processes on an everyday basis.

It would appear that in the classroom situation at the junior secondary school level the above arguments are quite valid and this underlined the Scottish Integrated Science course which aims to 'expose pupils to the work of the scientist, the apparatus at his disposal, experimental methods he uses, the different processes of thought by which he arrives at his conclusions.' The AAAS also has its project centred upon the idea that what is taught to children 'should resemble what scientists do - the process that they carry out in their scientific activities.' Indeed the Nigerian Integrated Science Project also has as one of

its cardinal aims the teaching of 'what science is' and 'how the scientist work' to the pupils.

In terms of the conceptual approach Jacobson, (1971); Eggleston, (1974) and Showalter, (1979) are of the opinion that the study of science under 'major ideas' is very fundamental to the development of the conceptual structures of science. This has led to the observation that there seemed to be a common set of concepts which serve as the bricks from which knowledge is built. Indeed some of the integrated science projects like the Schools Council Integrated Science Project and the Australian Science Education Project which are based on the conceptual schemes are said to have had a greater measure of success than any others (Brown, 1977).

3.3.3 Psychological and Pedagogical Arguments.

A group of arguments in support of integrated science concern themselves with the student, and the psychological and pedagogical factors that influence the learning situation. Claims have been made that integrated science provides an opportunity to present materials which are student-centred and hence more motivating (Whitfield, 1971). Thus a process approach as favoured by the Schools Council Integrated Science Project and SAPA might be expected to be more interesting and hence more motivating than the traditional approach. However there appears a lack of supporting evidence for this view in the research literature.

Transfer of training, the transfer of concepts and principles used in one discipline to another, has been one of the most contested educational principles. If Bruner (1966) believes transfer can occur substantially, then concepts and methods used in one science area can be used in another. Blum suggests that an integrated science curriculum can provide the opportunity for this to occur, particularly when considering the similarities between the various disciplines.

Arguments based on the stages of the intellectual development that children pass through are often used in support of integrated science. Thus Blum argues that science

education at the elementary level should be integrated "the term undifferentiated would be more appropriate", since it is more in keeping with the appropriate Piaget developmental level. Clearly a corollary of this argument is that children should be introduced to basic disciplines such as physics, chemistry, biology, etc. only when they can appreciate the theoretical structures of the disciplines. Plausible though this psychological argument appears to be, it is however doubtful that many students in these areas ever perceive these structures of these disciplines and on the other hand, an introductory chemistry or physics course can proceed from concrete to abstract just as well as an integrated science approach.

3.3.4 Science and Society

Another group of arguments widely used in support of integrated science is based on satisfying the needs of society at large and individuals in particular. Although many of these arguments are rational and cogent, many others far too often deteriorate into polemics. Before the validity of this argument can be assessed, a judgement as to the degree of accountability of the educational process to the society must be made. This degree varies at different stages of the educational process. Universities have traditionally guarded their autonomy and accountability. However schools represent a primary agent of socialization and as such can be expected to be responsive, at least to some extent, to the needs of the society. As far back as 1910, Albert Einstein, a great scientist, did state that the concern for man himself and his fate must always form the chief interest of all technical endeavours. And he therefore advised that scientists must never forget this in the midst of their diagrams and equations. Whitfield, (1971), however warns of the danger of basing curricula on the needs of the society as seen by various people, but in fact curriculum choice is in the final analysis a human process, and most materials reflect some kind of value judgement, either by individuals or group. The major need of society as seen by many writers is for a scientifically aware population, capable of insight into the many issues and problems facing the society. Since these issues and problems transcend the traditional demarcations of the school curriculum, then science courses designed to serve

the needs should be, according to this argument, interdisciplinary. Thus the quest for the utility of science for man's benefit leads to the integration of science which finally crystallising in interdisciplinary integration of science.

It is to achieve adequately all the needs of the society through science education that the integrated science curriculum seems appropriate and is being vigorously advocated in schools. The present trend in integrated science around the world however, seemed to be going beyond mere integration of science disciplines to accomplish the task of general education. What is being suggested (Lewis, 1978) is that there should be the aims of science in society component of science course which among other things will include:-

- (a) the understanding of the nature and limitation of scientific knowledge;
- (b) appreciating that the use of scientific knowledge can be both beneficial and detrimental to society and the environment;
- (c) appreciating that the earth's resources are finite; and
- (d) understanding the need for, and to develop the ability to make reasoned decisions which take account of all relevant constraints, to recognise that moral and political considerations are involved in decision making.

The review of the meaning of integrated science has revealed a variety of interpretations, which seems to suggest that it would be misleading to treat integrated science as a linear concept. All the same the variety of opinions about integrated science among the science education specialists suggested a shift from the aim of teaching science to produce only scientists to also one of promoting scientific literacy among a whole population. What must remain a matter of concern is how to arrive at such a curriculum for the integrated science education. The next chapter attempts to discuss the model for an integrated science curriculum.

CHAPTER 4

INTEGRATED SCIENCE CURRICULUM MODEL

In the previous chapter the meaning and rationale for integrated science education were reviewed. The picture that emerged was that integrated science has the aim of bringing school science education closer to science as it actually is, emphasising on the philosophy and sociology of science. The model for such a science education curriculum is the subject of this chapter.

During the past two decades emphasis in science education in both the developed and the developing nations has shifted from one of producing only an elite minority of scientist, technicians, engineers for industrial growth to one of promoting scientific literacy and critical thinking ability amongst the whole population. To keep pace with this new dimension in science education, educationalists and curriculum developers in many nations have stepped up projects to produce science curricula which fall outside of the traditional classification of scientific disciplines in order to help fulfil the expected additional role and cope with the new challenges. The period from the late 1960s to the '80s have witnessed an enormous variety of new science programmes- all of which may be titled 'Integrated science' programmes. Haggis and Adey (1979, 1986) observed in their review of integrated science education world-wide, that integrated science education is a rapidly developing and expanding educational field. They described a proliferation of integrated science education with data collected on 130 courses. The forces that have resulted in the production of these curricula are numerous and varied, ranging from the philosophical writing of educationalists to pragmatic realities of the classroom situation.

Even with this popularity which integrated science has been gaining around the world, various authors (UNESCO 1971, 1973, 1975 and 1977; Brown 1977, and Kirby 1980) acknowledged the difficulty of reaching a consensus on the definition of and rationale for integrated science. Black(1986) also admitted that even though the need to design a new science curriculum in place of the three separate sciences for all pupil^s/at

secondary level up to age 16 is self-evident, there is however, clearly no consensus on this matter, and at the same time, the principle^s on which a new integrated treatment might be based are nowhere clearly stated, let alone agreed.

Attempts to provide rationales for integrated science have resulted similarly with as many rationales advanced in support of integrated science curricula as there are the attempts to define it.

This chapter attempts to establish from the literature a theoretical model for integrated science curriculum. This will, together with some relevant issues established in chapter 3, form a theoretical framework necessary for analysing the Nigerian core curriculum for integrated science for the junior secondary school. It must be made clear here that the exercise intended in this chapter is not that of attempting to establish a 'standard' model for integrated science curriculum and use it to 'judge' the Nigerian curriculum for integrated science. Rather the aim of the chapter is to examine if there exist^s a general consensus on the model for integrated science curriculum. It is an attempt to explore the generally agreed principles for developing an integrated science curriculum and to see how far does the Nigerian core-curriculum go with or differ from the model.

4.1 INTEGRATED SCIENCE: A curriculum device or a discipline?.

It is not an unusual experience to find an emerging new field of study entangled in a myriad of unanswered questions. These questions not only arise internally from the practitioners of the new course but also from outsiders. Such questions, in most cases, are seeking to clarify the identity of the newcomer.

Integrated science is one such newcomer in the academic field, hence, as is the norm, several issues need clarification by its practitioners, not only to themselves, but also to other members of the academic community and the outside world. Prominent among these areas needing clarification are the *meaning* and *status* of integrated science. There is no intention to dwell on the definition and range of meanings held about the concept of

'integrated science' as this has already been exhaustively discussed in chapter 3 of this work.

From the definitions and range of meanings given to integrated science, it is apparent that it is a term used to describe a type of curriculum that has been developed by drawing its subject-matter from various science disciplines and in some cases, social sciences and other non-science subjects are also drawn upon. Technically the term 'integrated science' should be seen as a 'Curriculum device' rather than as a 'Discipline' in the academic sense.

As to what subject that meets the hallmarks of a 'discipline', Yager, (1984) has this to say "...the term 'discipline' is reserved for scholarly pursuits where there is a research base." Clearly integrated science does not meet this criterion as a science, only as in science education.

In his own opinion about 'the nature of disciplines', Westmeyer, (1983) said that a discipline can be defined in terms of the following four points:

1. - its being a field of study or a subject of teaching;
2. - its practitioners feeling a need to communicate with each other;
3. - the formation of a formal or informal organisation-a society; and
4. - the sharing of ideas and information among its practitioners through some sort of publication.

In a more radical approach to the issue of defining a discipline, Westmeyer concluded saying:

".....a discipline is a discipline precisely because its practitioners say that it is a discipline, and it requires no further justification. It does not have to be 'legitimised' for outsiders and its content does not have to be uniform among all its practitioners".

Watson, F.G.(1983) on the other hand sees the self-conscious effort to define what is and what is not a discipline as "a fruitless search for the Holy Grail"; adding that the society would accept any professionals who apply their disciplined skills to a variety of social decisions/problems. Watson might be right to some extent but perhaps the point

raised in respect of the society's role in the definition of a discipline could be regarded as an over-projection of the society in the issue of deciding or defining what should be and what should not be a discipline. The questions that arise immediately from this position is, should the professionals of any field mortgage their right to judge or decide on the legitimacy of their field as a discipline to the society which is only but a consumer of their endeavour? What then happens when the society fails to recognise and ascribe the term 'discipline' to the field whose professionals see it so? It might be appropriate for the society to play the witness role in issues as this, rather than being a major participant in deciding what should be a discipline.

However, whether integrated science is a curriculum device or a discipline, the crisis in integrated science lies not in the pressure to establish the legitimacy of its being also a discipline but I think much of its problem lies more in the description of its domain and perhaps a clear statement of its unique centre of concern. Since integrated science has been a growing field and is still a centre of educational activity, we hope that one day its practitioners will clear the vagueness and uncertainties embodied therein.

4.2 INTEGRATED SCIENCE CURRICULUM MODEL: Relevance, Scope and Intensity

The spontaneous work on development and improvement of programmes in integrated science teaching all over the world are not without some difficulties. Fundamental to these difficulties is the quest to find answers to strategic and important questions such as, "If we should integrate, what shall we integrate and how shall we do it?" These questions if properly answered should provide a universally appropriate philosophy and/or model for integration. Such a model should be capable of prescribing the scope and the intensity for integration as well as the principles for the integration.

Arising from the above question is the issue of making a decision on how far to go in the integration process:

- how many disciplines are involved: Scope.

- how intimately are the disciplines inter-connected: Intensity
- the vehicle for integration: Principles e.g. process, social issues, concepts.

4.2.1 Relevance

It is worth noting that within these past few years there has been a growing realisation that where science programmes are being developed they have, in most cases, been done through the process of adoption and adaptation. Of existing programmes it is essential that where curriculum development proceeds by adaptation, it should involve much more than the mere localisation of names, place and content; rather "the entire programme, including AIMS, GOALS and OBJECTIVES must be developed to suit the needs and wishes of the society for which it is intended"(Brophy and Pillay 1986). Experience has shown that many of the programmes which were introduced into developing countries, however were adaptations of courses originally produced for developed countries such as the United States of America and the United Kingdom. The original producers of these materials devised them for their own cultures. They not only made implicit assumptions about such things as the children's cultural experiences, conceptual range, learning styles and educational aspirations but devised the materials to achieve the aims , goals and objectives that were thought desirable for their own particular society. The problem is accentuated if the science curriculum has been borrowed from a wealthier country without due regard to the strain that its equipment demands may throw on the country's economy. D'Ambrosio (1979) could have probably had this picture of diverse needs of societies in designing his model for the components of an integrated science programme(Fig. 4.1).

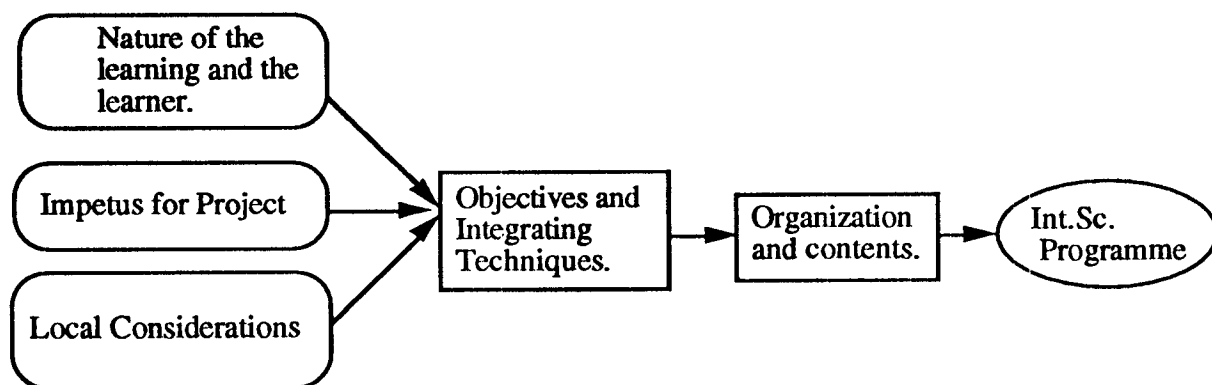


Figure 4.1: Components of an Integrated Science Programme (D'Ambrosio, 1979)

The above model suggests that, to formulate aims and objectives of an integrated science programme, consideration is given to the nature of the learning and the learner, the impetus for the project (i.e. what needs does the programme aims to satisfy or fulfil ?), and of course the local considerations. Once the objectives / goals / aims have been formulated, the selection and organisation of contents according to D'Ambrosio should then be an outgrowth of the project's aims, the nature of the students (their ages and experiences level), the local situation and the scope of science.

In the light of the uniquely diverse needs of societies, it is suggestive that the content of a course must , as a matter of relevance, be different for each country to be decided by its Government agencies, working together with teachers, scientists, and others involved and affected by the educational process. By implication therefore, it would appear that there can be no single model on which any integrated science curriculum can be modelled to suit every society. Hence it would be appropriate to conclude here that there can be no over-arching(all embracing) model for the integrated science curriculum the world over, although the various independent curricula can, to a large extent, share certain essentially common characteristics.

4.2.2 Scope and Intensity

According to Hacker and Rowe (1985), of the various meanings which have been ascribed to integrated science and various definitions which have been proposed, perhaps Blums' (1973) matrix provides the most useful operational classification system. Using the matrix, the extent to which a particular programme is integrated can be shown, hence it will be useful in describing and comparing integrated science programmes. The matrix however does not show what content should be integrated and how this can be done. This matrix has two dimensions or axes which represent SCOPE and INTENSITY. Blum defined these dimensions as follows:

SCOPE:- this refers to the range of disciplines and fields of study from which contents have been used in an integrated science curriculum. In other words, the scope of integration is the number of disciplines, scientific or other-wise, whose contents have been combined to form the integrated science curriculum. According to Blum, the scope of integration gives us an indication of whether the integration was made between similar disciplines or between traditionally removed ones. On the basis of widening scopes of integration, Blum outlined the following differentiations:

1. Within one of the natural sciences e.g. botany and zoology integrated in biology; arithmetics with algebra and analytical geometry in mathematics.
2. Between two close natural sciences e.g. chemistry and physics as physical sciences or chemistry and biology or any two of the disciplines commonly taught as separate subjects from the senior secondary level upwards. The course 'Structure of matter' from the university of Palermo, Italy is an example of this type of course, coordinating chemistry and physics as physical sciences.
3. Between the natural sciences (with or without mathematics) The Scottish and Nigerian integrated science curricula are good examples.
4. Between basic and applied sciences and technology.
5. Between natural sciences and social sciences.

The Schools Council Integrated Science Project in the United Kingdom, many of the curricula from the United States such as the Unified Science and Mathematics for Elementary schools, and the 'Environmental education in the primary schools' from Norway are all examples of categories 4&5.

6. Between sciences and humanities e.g. the former Primary Pilot Project from Singapore in which science activities were used essentially as stimuli to the development of language skills.

INTENSITY:- this refers to the degree to which the subject matter has been truly integrated. In other words, the intensity of integration is a measure of the extent to which the separate disciplines are blended, it describes how much of the contents of each discipline have been integrated in the science curriculum. Blum describes three levels of intensity of integration namely: coordination, combination and amalgamation.

COORDINATION: A coordinated science curriculum is one where the separate units of the blended disciplines (e.g. physics, chemistry ,and biology) can still be identified, but they have been linked together to give a continuous curriculum with its own structure. This notion of integration involves the creation of connections between the various science subjects. In this case, integration would not simply deal with organisation questions but logical questions about the relation of one subject-matter to another. In fact, behind this notion of integration is the belief that there is logically distinct subject matter and that these distinction need to be respected in teaching integrated science. This issue of coordinated science curriculum, according to Blum, would usually apply to independent programmes taught simultaneously, which are influenced to varying degrees by a common agency e.g. an educational authority or planning committee. Examples include the Junior High school science courses in Israel, and the '*Perfectionamiento en Servicio, Ciencias Naturales*'(PPS-CN) from Chile.

COMBINATION: A combined science programme would involve developing chapters or other major units organised round headings taken from the different

disciplines. Examples include the 'Basic Science' from Fiji and the Nuffield Combined Science in the United Kingdom.

AMALGAMATION: In this programme, an inter-disciplinary topic(theme) or issue(problem) from the environment would be taken as its integrating or unifying principle at the chapter level. It is a curriculum that has been developed from the 'other end', as it were: ideas which may be associated with separate sciences are called upon as they are needed to cope with problems as they arise from the environment of the learner. Examples include the integrated science curriculum of the Tokyo Institute of Education and the SCISP of the United Kingdom.

In summary, the scope of integration really defines the subject matter range while intensity is dependent on the organisation of the curriculum.

Blum also introduced another dimension for integration besides the dimensions of scope and intensity. By drawing attention to the involvement of the environment as another dimension for integrated science, Blum intends that it should be able to give information on how far an integrated science programme is involved in a range of problems posed by the environment of the learner - does it lead to the personal profit of the learner as in the form of projects e.g. as used in vocational agriculture in the United States? Does it involve the development of the village and educate towards national self-reliance, e.g. in the Tanzanian and Nigerian projects or does it look at problems affecting the biosphere and Man's place within it? Integrated science teaching, according to Blum, is not complete without environmental involvement. Certainly, this is not an over-statement by Blum especially when one considers the fact that most definitions of integrated science collated by D'Arbon (1972) contained the educational aim of " helping the student to gain an understanding of the role and function of science in his everyday life and the world in which he lives". It becomes necessary and important, therefore, that in describing a science curriculum, its position as to environmental involvement should be clearly pointed out.

4.3 PRINCIPLES AND APPROACHES FOR INTEGRATION

Since an integrated science programme could theoretically include all of science and its related disciplines, curriculum developers must find a design to facilitate the selection and integration of contents. To this end D'Ambrosio(1979), Holbrook and Rosier (1990) proposed two general approaches:

1. The melding of scientific knowledge based on the underlying concepts and processes of science;
2. The use of integrating themes from life experiences (phenomena and persistent problems -environmental considerations), that require an understanding of many areas of science. The diagram below(Fig. 4.2) illustrates this view.

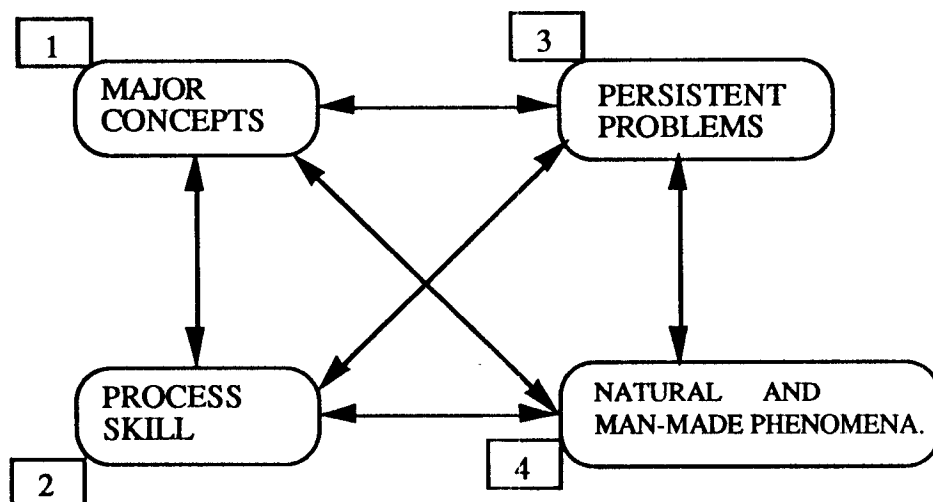


Figure 4.2 : Integrating Strands For Integrated Science Curriculum.
(ICASE & D'Ambrosio, 1979)

-1 and 2 are organising themes related closely to disciplines.

-3 and 4 are organising themes related to the learners and their environment.

Many principles are used to integrate a science curriculum as is evident from the above integrating strands. Some of them are inter-disciplinary topics(concepts) and draw their integrated content from different science subjects. The posing of an environmental

problem like pollution, hunger, and population problems can be another useful integrating principle.

Integration is not necessarily built on content; other principles of integration are, for example, a common method such as inquiry training, problem-solving, processes in science, etc. These possible integrating principles come from different dimensions of science or education. Two or more of them can be used concurrently.

All modern science teaching courses, integrated or not, tend to be **laboratory and inquiry based** involving a good deal of individual activity, exploration and the building of understanding through practical experience, together with a consideration of second-hand experience and discussion of social implications. Even within the inquiry approach, the focus of attention differs from course to course. There are a large number of approaches on which integrated science teaching curriculum are being developed (Hall, 1973, Orevbu, 1990). These are as follows:

4.3.1. Process Approach:

This approach claims a direct descent from the ideas embodied in the United States primary science course, Science -A Process Approach(SAPA) (AAAS, 1965) which was based on the view of 'Science as Process' outlined by Gagne(1965). Process are ways "of processing information". For instance, the Warwick Process Science Programme, in describing what is meant by 'process', states that 'one is looking at the sequence of events which are engaged when researchers take part in scientific investigation.....observing, inferring, classifying, predicting, controlling variables and hypothesising(Screen in Millar & Driver, 1987).

In Gagne's view of 'science as process', he argued that prerequisite scientific concepts and principles are obtained only through the operation of science processes, such as observing, classifying, describing, communicating, drawing conclusions making operational definitions, formulating hypotheses, controlling variables, interpreting data and experimenting. He argued that these processes are skills used by all scientists, they are applicable to investigation in all sciences, they can be learnt by students and be transferred

across content domains. The Scottish Integrated science course contains a similar list of processes under the heading 'Ways of thinking' (SED, 1969 in Millar & Driver, 1987).

4.3.2. Concept Approach:

In this approach, all course work is directed towards the major concepts of science. The concepts are not studied in their entirety at once. Each one is spread out over the length of the course, leading to coordination of the flow of development of an idea with age of the student.

4.3.3. Thematic Approach:

The Nuffield Secondary Science Project in the United Kingdom falls into this category. Here, themes are sub-divided into fields, each theme is loosely structured, as is the overall scheme, for example, the theme "The world around us" is divided into eight (8) fields. However, the structure of a particular theme is disregarded in the presentation of the subject, for teachers are encouraged to select fields from themes in order to build their own courses. A major draw back to the course is that the teacher does not only find difficulty in selecting but also in developing a set criteria (aims) by which selection for a given purpose may be achieved. The strength of the scheme (i.e. flexibility to allow for individual requirements) could also be the major weakness, for although overall balance and structure are possible, great care needs to be exercised when selecting a route through the materials in order to avoid a somewhat disjointed or unbalanced course.

4.3.4. Topic Approach:

The Nuffield Combined Science for ages 11-13 in England uses this approach, based on certain concepts; 'Focus', 'Probe' and 'Pattern'. It seems to have relied on the principles in the thematic and conceptual approaches. However, in the Topic Approach, any number of self-contained topics may be studied in any order. Although each topic may be well structured within itself, if there is to be flexibility in choice and order of presentation, then there can be no overall structure to the course. One disadvantage of such a scheme is that

the way a topic is taught to a 11 year old will be the same way it is taught to a 13 year old. The whole picture for any concept must be presented, immediately, instead of developing it as the course progresses. Except the teacher manipulates the course to meet the needs of the pupils.

4.3.5. Environmental Approach:

This is the model employed by the Nuffield Junior Science Project in the United Kingdom, the Mauritius Integrated Science Project, the Australian Science Education Project and the African Primary Science Programme(APSE). It is particularly applicable and useful to junior schools but because of its almost completely unstructured nature, may be of little use outside the country of origin. However, even at the secondary stage, every encouragement should be given to schools to use their own environment.

4.3.6. Project Approach:

Teachers following the recommendation of the Nigerian core curriculum for the junior secondary school integrated science make use of project in their work. Few teachers in secondary schools would advocate the exclusive use of projects in the classroom, but they can be used to great effect at intervals, perhaps, once or twice a year.

4.3.7. Applied Science Approach:

The starting points are the country's important industries. Although this makes teaching quite relevant to the child as well as giving him first hand experience, one major disadvantage of the approach is that large areas of science would probably not be covered, although one form of integration could be achieved through the study of particular industries.

4.3.8. Patterns Approach:

This approach forms the basis for School Council Integrated Science Project(SCISP)- a curriculum project for integrated science developed in England in the 1970s. It was used for the G.C.E. O/level population of 13-16 years old age range, but is now modified and forms the basis of a double certificate 'Science' course for the GCSE. The project model(SCISP), was devised only after a careful analysis of the seven major ways(discussed above) in which existing science courses were being taught(Hall, 1973). The model may be regarded as a combination of **concepts** and **process** models and represents a search for patterns in sciences and the use of these patterns in solving problems. A Pattern by definition means a **generalisation** and is exclusive to the SCISP model (see section 4.4 below)

The SCISP was developed on the basis of a learning model proposed by Robert M. Gagne(1970) in which it is suggested that the process by which we all learn is a hierarchical one which begins by the storing of bits of information in the brain memory locations. Consciously or unconsciously, these bits are collected into peculiar groups possessing common characteristics called **concepts**. Once labelled, these concepts are joined into a complex array which SCISP called **Patterns**, which may be constantly modified and extended in the light of new experiences. It is the search for these patterns and their subsequent use in the solution of problems which form the rationale behind the SCISP course. The problem-solving aspect represents the most sophisticated stage of learning process and is placed at the top of Gagne's learning hierarchy.

In fact the emphasis is more on the **Process** involved in science rather than the factual content characteristics of traditional science courses. The selection of the input materials which initiates the building of the hierarchical structure is left largely to the teacher's discretion.

4.4 THE SCHOOL COUNCIL INTEGRATED SCIENCE PROJECT (SCISP) MODEL

Learning experiences take the form of practical and theoretical investigations, practical and theoretical problems, the reading of background books, class discussion and teacher demonstration. The pupils thinking is developed by considering three fundamental concepts:-

1. Building blocks.
2. Energy.
3. Interactions.

The subject matter of the whole scheme is based on these three useful and fundamental concepts of science around which pupils are expected to organise their thinking.

The most important integrating theme of integrated science is to show that the basic activities of science are common to all branches of the subject. Although these activities include observing, classifying, measuring, predicting, etc. the ultimate(knowledge) activities in the patterns approach are:-

1. the search for patterns, where patterns mean a generalisation.
2. the use of these patterns in problem-solving(whether of laboratory, or a theoretical or an everyday type).

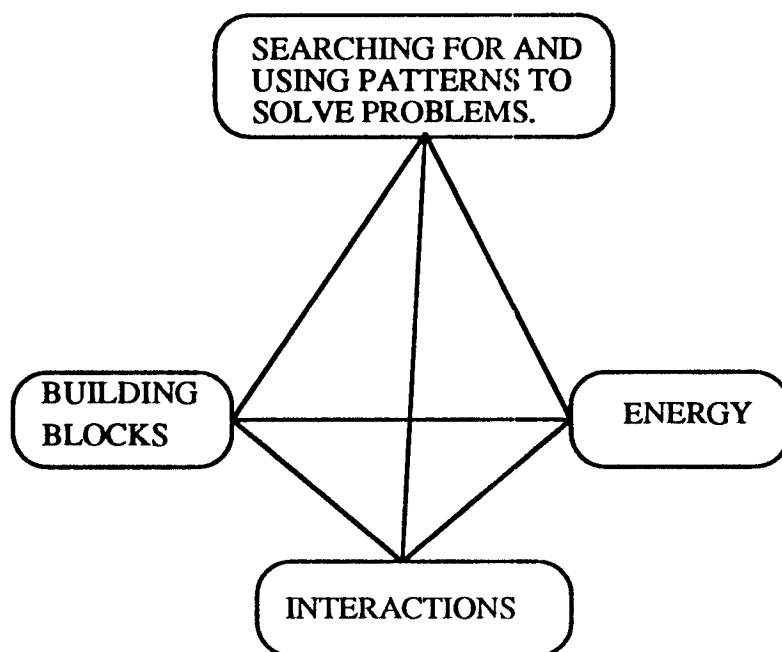


Figure 4.3 : SCISP Project Model.

[content is based on these three fundamental concepts; the most important integrating theme(on a different dimension) is the search for and use of patterns].

4.4.1 The SCISP Learning Model

Levels of learning:

Four levels of learning were defined in SCISP: the word 'knowledge' being the general term applied to all four of the levels which are labelled **Recall, Concept Learning, Patterns Learning and Problem-Solving.**

Recall: The simplest definition of recall is the 'calling back of that which has been committed to memory'. A great deal of information is committed to memory and so the process of discrimination is important in recall.

Concept Learning: When things which have a common property(or properties) are grouped together we have a concept. Recall must play a large part in concept learning. Concepts can be usually be defined formally, but it is possible to understand a concept 'intuitively' and yet not know the formal definition. Also it is possible to know the formal definition and yet not understand the concept(this is a case of rote learning).

Patterns Learning: Formal definitions of concepts are very often in form of patterns. Some might suggest this is how concept should be taught; others believe that the 'feel' for the concept should come first.

A Pattern is a relationship between concepts and expresses a generalisation.

In Pattern finding, data are examined by pupils, the understanding of which relies on previously learned concepts and pupils are asked to extract a pattern from information.

Problem Solving: In order to solve a problem, a student must recall from a large number of patterns, and use a particular pattern(or patterns) to solve the problem (At this stage SCISP deviates slightly from Gagne's model: he states that at least two or more principles are required to solve a problem).In other words, in problem solving a pattern must be recalled and is then applied to unfamiliar situations.

A Summary of how the four types of learning are connected is shown below. This is the SCISP Learning model and shows how the process dimension of the project model is achieved(FIG. 7).

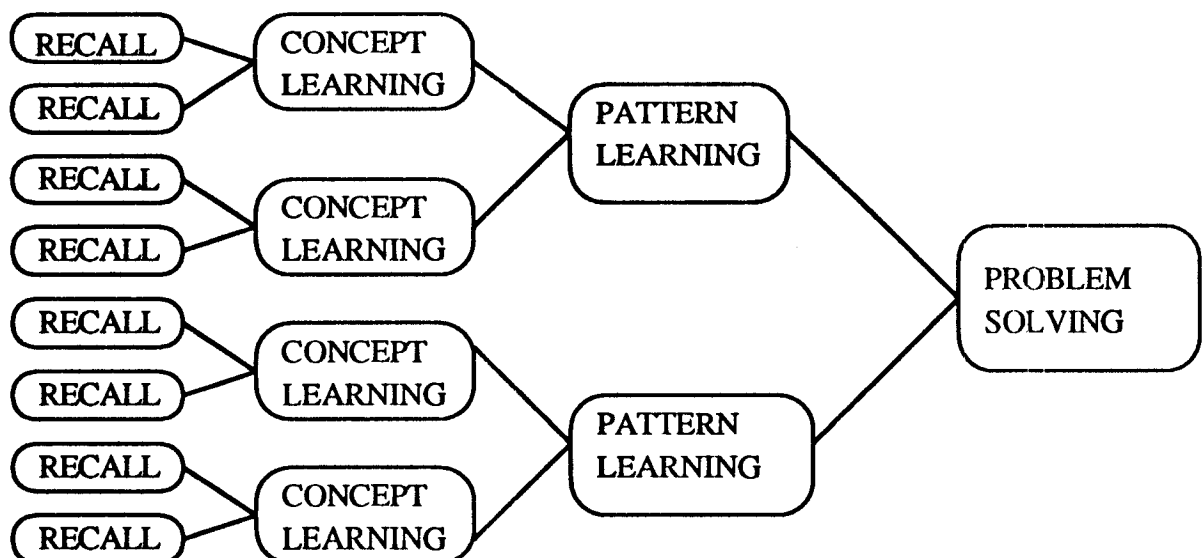


Figure 4.4 : SCISP Learning Model (Gagne; 1965)

It can be seen from the diagram that problem-solving requires as a prerequisite a pattern or patterns; patterns require as prerequisites concepts and concepts learning relies heavily on recall of past experiences.

One reason why the decision to produce a 'patterns approach' to science teaching with emphasis on concept learning was important was in order not to make mistakes similar to those which were made by General Science(Hall W.C., 1973). He listed the following reasons as having been responsible for the failure of General Science in schools in the 1940/50s in the United Kingdom:-

1. General Science was partitioned into three areas(physics, biology, chemistry) which had been traditionally taught.
2. The school certificate examinations reflected these divisions.
3. The schemes were entirely content based.
4. It was usually examined as a single subject and was given a correspondingly small allocation on the school time table.
5. Not enough help was given to teachers to assist them to teach outside their own disciplines.

These reasons also hold very strongly for the Nigerian situation in the case of both the General Science of the 1960s and the integrated science now. The case, to a large extent, is similarly true of most developing nations that are running the general/ integrated Science courses in their school curriculum.

The SCISP learning model is process-based; the process ignores subject boundaries; the assessment procedures are based on the learning model and not on particular content areas. These factors ensure that the reasons 1-3 mentioned above cannot be labelled against this integrated science course.

4.5 CONCLUSION

This search for an ideal model for integrated science curriculum leads to the following conclusions :-

1. There is no prescriptive over-arching model for integrated science curriculum nor is there a possible emerging picture of one in the very near future. It is most likely that a generally relevant integrated science curriculum model for a wide application will continue to be a dream as long as there is no consensus on the general concept of Integrated Science. In addition the impetus for such projects must arise from the primary needs of the nation and to respond to needs and circumstances of pupils.
2. A useful, relevant model for an Integrated Science curriculum can only emerge from within a national boundary that has the need to operate an integrated science education.
3. How well an integrated science curriculum has been '*integrated*' (blended or interwoven) can only be defined in the context of its concept and objective(s) unique to itself.
4. In spite of the diversity in models and approaches to the integrated science curriculum, they show a very high level of commonality in purpose and goal. The variety of approaches to integrated science education suggest that, at worst the description is a label for any course of science instruction which attempts to embrace a number of issues which includes:
 - i. many science and science-related disciplines;
 - ii. the processes of sciences;
 - iii. an attempt to show the common ground of many scientific activities - some fundamental unifying principles of science;
 - iv. key scientific concepts as important explanatory models of sciences;
 - v. environmental issues;
 - vi. materials which addresses the use and impact of science on society.
5. There is a need to question the use of the term 'integrated', in the phrase 'integrated science'. Does it add anything to the simple word 'science'? Adopting such a course of

action leaves open the question of organisation and allows curriculum developers the same freedom to develop structures and content in the light of national needs. Nevertheless, label or not, a course will be structured on some philosophy related to education and science even if it is implicit, rather than explicit. Such a strategy avoids arguments, however, about the philosophy of integrated science.

6. The integrated science curricula examined in this review have shown to have achieved their integration (blending and organisation) through various approaches: Concept, Topic, Process and so on, as illustrated in Fig4.5 below. An extra level of organisation is provided for some curricula by **Psychological Considerations**. For example, the 'Science 5-13' in the UK., the Australian Science Education Project, follow a Piagetian model of development in matching concepts to the developmental levels of the pupils, while the SCISP in the UK. uses learning hierarchies based on the learning theories of Gagne.

In producing this pattern of integration models (Figure 4.5 below), it is not claimed that all the existing integrated science curricula have been examined, rather the design of this model drew heavily on reports on integrated science education world-wide UNESCO(1990) and Haggis & Adey,(1978, 1979, 1990). It is at least with confidence to say that the pattern is a representative model of the patterns for many integrated science curriculum development and integration world-wide.

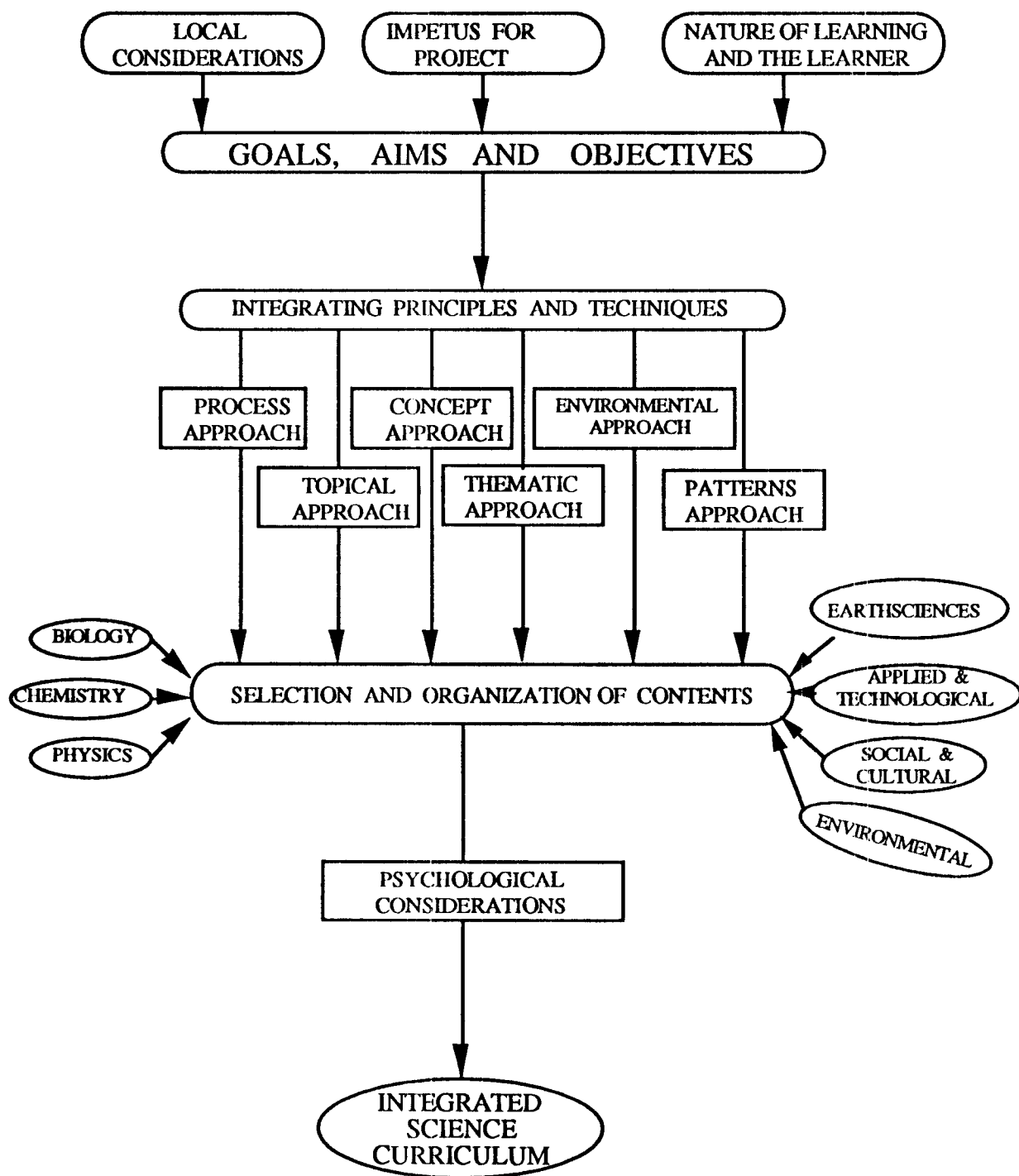


Figure 4.5: Development and Integration Pattern for Integrated Science Curriculum.

7. It is my impression that in all the curriculum studied the application of the integrating/organising principles are interwoven with one another and it becomes difficult to identify or associate any one curriculum with only one type of the integrating principles; indeed it would be a narrow curriculum that relied on just one model. Hence an integrated science curriculum may be seen to have used one or more integrating principles in its

design. In any case what lie at the core of my beliefs about an appropriate science curriculum (however classified), are the aims identified by Layton, summarised in Reay (1993) as follows:

- (i). **Science as a body of knowledge:** This is seen as including, not only the facts and concepts, but also the humanistic aspect - a need to convey the body of knowledge, tentative still, as marvellous achievement of mankind.
- (ii). **Science as a way of working:** Process skills are clearly involved here, but they are only part of the scenario. Depending on their levels of maturity, children also need to develop appropriate attitudes in science, for example, curiosity and respect for evidence. Inquiry and problem-solving opportunities are required, as well as deliberate teaching which makes children aware of their progress towards acquiring scientific skills and attitudes. Perhaps science teachers would find it easier to reflect science in the classroom if they were conscious that scientific approaches to exploring the world are themselves a creation of humanity, begun only some 400 years ago.
- (iii). **Science in its social context:** For younger children, the emphasis would be science in the home and in the neighbourhood. As the children mature, one would expect curriculum to attend to wider issues of technology and society, together with certain skills and attitudes for life.

We can see at once that such a curriculum would demand the most insightful and confident teachers. What should be a matter of concern is to help the teachers with up to date concepts of the aims and nature of the science curriculum. Our next chapter discusses the training and competences a teacher of integrated science would require in performing his role.

CHAPTER 5

THE EDUCATION AND TRAINING OF INTEGRATED SCIENCE TEACHERS.

The goal of this chapter is to identify the characteristics thought to be desirable for beginning teachers of integrated science or science teachers. If a coherent set of characteristics can be identified, then together with models used to describe integration in science curricula and their application to the Nigerian science curriculum, it may be possible to examine constructively current practises in initial teacher education for integrated science teachers.

5.1 INTEGRATED SCIENCE - A challenge to the science teacher.

During the past thirty (30) years of intense science curriculum development and implementation, it has become increasingly apparent that there are no instructional materials which are 'teacher proof' (Showalter, 1974). That is to say, designers and writers can conceive and produce some instructional materials which enable learners to achieve almost any goals; however, when placed in the hands of teachers, the materials all too frequently get used in ways and towards achieving objectives other than those which the designers intended.

There is no doubt about the increasing interest in integrated science throughout the world, as many countries now teach sciences both at elementary and lower secondary level through Integrated Science Programmes. Since the emergence of integrated science programmes, there have been the unfolding of a vast array of integrated science teaching projects and programmes in every corner of the globe. These programmes embody a wide range of different approaches to integrated science teaching, including 'process',

'concepts', 'environmental', 'thematic', 'projects', 'unit', 'applied science' and 'patterns'. There are doubtless others, and in any case, as earlier observed in my review of models for integrated science curriculum development, it is rare to find a programme which makes use of one approach only.

A major constraint in implementing these programmes is the teaching challenge which they present to the science teacher. On the nature of this challenge, Haggis, (1974); Ogunniyi, (1983) pointed out that modern integrated science courses present their challenge through their teaching methods and the scope of the course. On the teaching method, they said that even though the new materials provide a wealth of ideas, stimuli and assistance for teaching, the teachers needs to learn how to handle them for positive results. Teachers are expected, for example, to make greater use of local materials from the environment, to engage in individualised instructions, require to handle 'open-ended' problems and situations; to utilise effectively a range of technological aids in addition to the more usual laboratory skills and more may be required of the teacher^s in terms of classroom skills such as asking questions, encouraging discussions and stimulating fruitful interactions among their pupils. Such teaching certainly provide great scope and flexibility which the teacher may need to be helped to know how to exploit it to the full. The course is usually wider in scope possibly including aspects of technology and social science. There may also be more understanding needed of the process of scientific investigation, the 'big ideas' of science - concepts, the unifying principles which the teacher is expected to have a good understanding of their significance throughout the spectrum of the sciences.

Teachers of integrated science therefore need to understand the broad concepts and processes of science as well as in pedagogy. Various techniques and learning theories for motivating and communicating with the learner are needed so that the benefits of discovery or open-ended learning, involvement of students in decision-making and conveying the social relevance of integrated science will be productive for the learner. The concept of integration will also need to be clarified to enhance the teachers' professional capabilities.

The teacher also needs to have an understanding of his pupils' capabilities and their level of cognitive development. An understanding of his^{her} pupils' strength and weaknesses

and their stage of cognitive development is essential if such an approach like individualised instruction is to be effective.

Teachers are therefore prone to fail to achieve any real integration of this sort in their teaching partly due to lack of guidance in how to do this, for rarely do teachers training courses prepare them adequately for a unified approach to their teaching. Teachers, it is said, often teach as they themselves were taught; certainly for the teacher who is to teach integrated science, a major change in approach is required for, as far as integrated science is concerned, a multiplicity of approaches confronts him. He may or may not have some choice in the question of which to follow. What ever course he follows, it will certainly demand much more of him in various ways than has hitherto been required of the single science discipline teacher. He might not even be too sure of his role and therefore may feel too uncomfortable about the new roles which many integrated science programmes call on him to fulfil (Haggis, 1974). All of the preceding discussion leads to the inescapable conclusion that the teacher is the key to developing successful integrated science programme and therefore requires a considerable attention.

Most projects today, in a bid to assist the teacher in his job, play down the syllabus and tend to work far more on teachers' guide and materials which exemplify an approach determined by the aims and objectives. Hall, W.C. in Richmond (1974) observed that this is where difficulties often arise; that it is very easy to construct a new syllabus but it is much more difficult to define a teaching style and even more difficult to ensure that teachers adopt the style in the way intended. He added:

teacher trainers face an awesome task, so many objectives which they write down deal with changes of attitudes. These attitudes are often deeply ingrained and to ask the teacher to change a large number of them is optimistic (Richmond, Ed., 1974).

Hall, however, believes that the key to changing attitudes is to provide resources and opportunities for teachers to become confident in their teaching. Once confidence has been achieved attitudinal change can follow. The teacher therefore requires a concrete positive help.

5.2 THE OBJECTIVE OF PRE-SERVICE TEACHER EDUCATION FOR INTEGRATED SCIENCE.

Implicit in the preceding discussion is the observation that the major constraints to effective teaching of integrated science are the material resources and the quality and perhaps the quantity of human resources available to teach it. The question of quality is in part at least about the preparation of teachers for integrated science teaching. This in turn raises the question of what desirable competencies or characteristics are required of an effective teacher of integrated science. Before taking a look at this, it seems relevant however, to review the goals and objectives of teacher education for integrated science, for according to Balogun, (1983), a clear identification and specification of system's objectives is a useful preliminary for identifying system's requirements for achieving the objectives.

Since integrated science and indeed science education as a whole is a sub-system of general education, there are, besides the more specific science education objectives, some core objectives which any pre-service science teacher education programme shares with the rest of the education programme in the training of teachers. These core objectives for teacher education and the specific objectives for science teacher education as well as the goals for education of integrated science teachers at the primary, secondary, and tertiary^{level} was one of the major focus of the ICSU conference on the education of teachers for integrated science, held at Maryland, U.S.A, April, 1973. These objectives and goals as outlined by the conference (Richmond, 1974) and Balogun (1978,1983) are as follows:

The common objectives for pre-service teacher education included:

1. To relate teaching activities to the nature of the natural, artificial, and cultural environments of his locality, country and in general, the whole world.
2. To relate teaching activities to the stages of physical, social, intellectual and emotional development of the child.
3. To know the cultural background and values of the people and make use of these in teaching.

4. To be responsive and to evaluate suggestions and questions of others involved in the educative process.
5. To pursue relevant areas of study to a greater depth.
6. To know the place of science education within the whole of general education.
7. To be aware of the educational technology available for teaching and be able to select the most appropriate for a particular course of study.

The specific objectives for science teachers were stated as follows:-

1. To demonstrate awareness of the place of science education in the whole of general education.
2. To use a variety of teaching approaches including the ability to establish an atmosphere conducive to children inquiry.
3. To be able to suggest or devise experiments which include the use of materials available around the classroom or out-door environment.
4. To demonstrate awareness of the theories of learning and their application to the understanding and use of scientific concepts and processes based on the child's development.
5. To know the child's previous and present experiences including those outside the school and the ability to use these in science teaching.
6. To have some common body of knowledge in the different areas of science in order to understand the wider aspect of what is to be taught.
7. To be able to design or describe a conceptual structure for integrated science.
8. To be competent in the various processes of science.
9. To understand the relationships between science, technology and society and to attempt to perceive an overall picture of the effects of solving one problem on the total environment.

The specific goals and objectives of teacher education for integrated science at the primary, secondary and tertiary levels were also produced as follows(Richmond, Ed. 1978; Balogun, 1983):-

5.2.1 Primary Level.

1. To learn content and ideas in integrated science.
2. To examine the programmes and materials that are available.
3. To learn the method of science that are particularly related to integrated science.
4. To develop a scheme such as a web or a structure around which a teacher can develop his integrated science programme.
5. To find how to broaden present discipline-oriented course so that cross-relations are evident.
6. To look for the aspect of culture that can be linked with integrated science.
7. To develop a spectrum of courses and units in integrated science so that no teacher will be unable to cope.
8. To lead to a tolerance for an idea of science that is not 'as clean as possible', so that teachers will enlarge their idea of science and its implications.
9. To develop a readiness to look at science in view of the needs of a country or a community.
10. To frame a type of programme in integrated science to ensure that training college students have a satisfactory idea of science.

5.2.2 Secondary Level.

1. To develop scientific attitudes to enable him to use them in decision making processes.
2. To understand the impact of science and technology on society.
3. To understand the role of science in the history of development of humanity.

4. To develop the ability to draw from a variety of sources.
5. To help the teacher realise his role as helper or facilitator of learning activities of children in and out side of the classroom.
6. To give a broad background in science with a deep knowledge in certain areas, possibly of an integrated nature such as energy, structure of matter, earth sciences etc.
7. To give an experience of personal involvement in research type activities.
8. To have an understanding of the learning process as well as sensitivity to detect the needs and interests of children, and the flexibility to adapt and modify the programme to meet these needs and interests.
9. To develop manual skills for using simple hand tools to improve science teaching aids from local resources if needed.
10. To find how to broaden present discipline-oriented courses so that cross-relationships are evident.

5.2.3 Tertiary Level.

Integrated science at the tertiary level should be aimed at training teachers of science at the secondary school.

Higher level integrated science can be achieved by first studying the separate science disciplines or by studying integrated science through out.

The preferred training institutions would give qualification in science and in education.

Scientific and educational international organisations should catalyse the interaction of specialists to study the problems of integrating content at the BSc level.

In addition, the following general considerations at all levels were listed for teacher education in integrated science:-

1. To equip students leaving secondary schools adequately to face life if they prefer to discontinue their education and to form a sound background for those who pursue the university training.
2. To train teachers in integrated science would prepare them not only to teach integrated science at the various levels, but with the appropriate curriculum, they would be able to even conduct research in curriculum development.
3. Since integrated science as a subject should in their view be based on the environmental and sociological conditions, rather than the classical aspects of science subjects, the person trained as a teacher of integrated science is bound to be a more useful member of the community than ~~he~~^{she} is now.

These three levels of objectives, although, developed by three different groups during the Maryland conference have each raised a clear concern about the teachers' knowledge of the content of integrated science. The primary group however, modified this concern with the need for flexibility in design and approach of a programme so a teacher would feel confident and competent to teach some integrated science even if his^{her} content background was quite limited. The tertiary group, at the other extreme, was so concerned about the question of content that they called for the interaction of specialists under the sponsorship of the international professional societies to determine what is involved in integrating science at the B.Sc. level. One possible approach of the question of content preparation in integrated science is given in item number 6 of the goals under the secondary level. This question of content and competence is also related to the ideas expressed in the first and the third goals reported under the tertiary level. I think the question really here is not just what content to include, but rather content for what? These points of view have been dealt with in chapter 4-'Integrated science curriculum model'.

Besides the concern about the teachers' knowledge of the content of integrated science, there is also an extremely high concern^{about} the role of the teacher^s in the classroom and ^{their} ability to present integrated science in a way that goes across not only the subject but the spirit and approach which is science itself. In addition, there is also considerable emphasis on the desirability of helping the student^s to see the relationship of science to their

culture and environment and to help ^{them} see how ^{they} could use science to make decisions about and improve life for ^{themselves} and ^{their} associates.

A general consideration of the goals at the secondary and tertiary levels gives one the impression that, essentially, science at the secondary and tertiary levels has at least two major goals. First, there is the pre-professional and professional training of those who will become producers in sciences and related fields. These individuals therefore need specific knowledge and competencies, many of which are directly related to and/or are a part of the specific study of specific scientific disciplines. The second major goal is the provision of a knowledge, appreciation and understanding of science and the approaches of science for the entire school population at the secondary and tertiary level. Since the leaders of the local community and the country at large, tend to come from this more highly educated group, the need for a knowledge of science and its possibilities and limitations, as applied to problems of life, is most important.

In summary, all the three levels objectives for teacher education for integrated science generally has the target of building into the teacher the appropriate scientific knowledge, skills and attitudes that can be applied in a wide variety of real life situations.

5.3 DESIGNING PROGRAMMES FOR THE EDUCATION OF TEACHERS OF INTEGRATED SCIENCE.

In discussing the question of designing programmes for the training of teachers of integrated science, Foecke(1974) presented an overall framework of reference depicting the task of the designer of such an educational programme. In principle, he said, the framework is sufficiently general for it, with at most minor modifications, to be relevant to the design of any educational programme-of whatever duration, level, type, subject etc. His framework is illustrated in the following diagram:

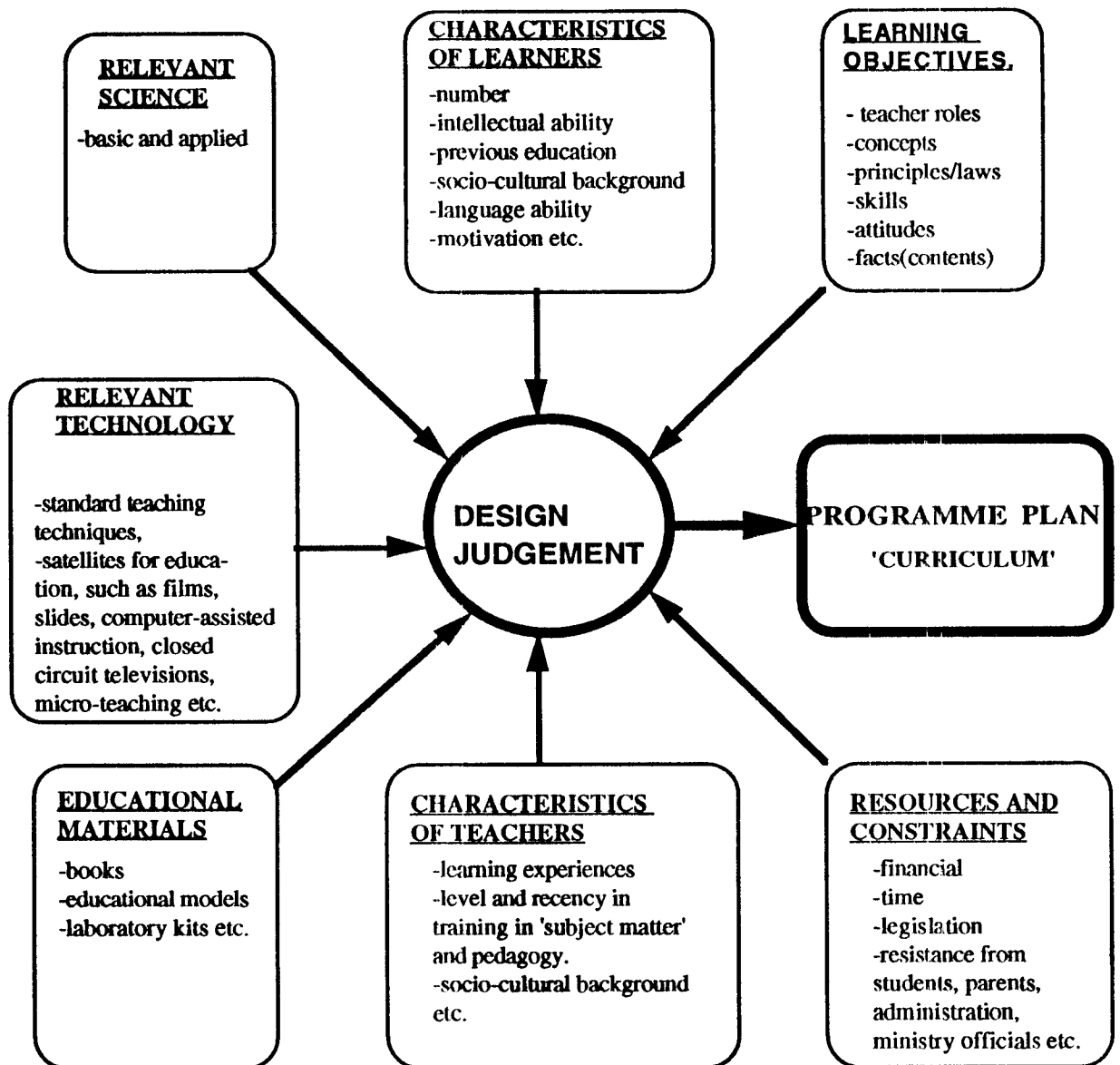


Figure 5.1: Inputs to the Design Process of a Programme for the Education of Integrated Science Teachers.

If a programme designer is to develop an optimum educational programme for the education of teachers, especially a programme that is to do the best possible job under the conditions that apply, a proper account of a large number of factors must be taken. Some of the most important of which have been shown in figure 5.1 above as inputs to the design process.

Speaking in terms of the education of teachers with respect to the different inputs in the diagram, Foecke feels that perhaps the initial starting point is to consider the **objectives of the programme**. In other words the designer must know what things the

future teacher is expected to learn. An approach to this level of objectives, if to be done properly, requires the understanding of the various possible roles of the teacher which varies with the level, country, situation etc. Some of the teacher's roles are suggested by the terms like, 'objective specifier', 'learning facilitator', 'programme designer', 'achievement evaluator', 'materials designer' etc. (Foecke, op cit.); each of these roles requires, for its proper execution, different understanding and skills. Self-evident as it may sound, a programme designer for the education of teachers must therefore carefully analyse what various roles the teachers are in fact going to play in order to design optimum programmes to prepare them for the tasks. In addition to these skills and attitude objectives, in designing a programme for the education of teachers of integrated science, it would be exceedingly important that it be clearly specified what these future teachers are themselves to learn in the area of science and technology. What concepts, principles, skills, etc., are the teachers expected to learn; if teachers are to help students learn the processes and product of science and technology, what and how much must they themselves know?

The next factor which the educational designer must consider very carefully are those **characteristics of the students (learners)** which affect the way in which they might respond to the learning experiences provided to them. Of significance to consider in designing a programme for the education of teachers, are such characteristics of the students as their number, intellectual ability, motivation, previous education, socio-cultural background, physical and emotional health, language abilities etc. Indeed one of the many reasons why educational programmes usually cannot be merely transplanted from one country to another is the very important differences in the characteristics of the students.

A knowledge of the previous exposure of the teacher trainees to science and/or technology is important for planning the details of a programme for training of such teachers of science and technology. This is because it may be necessary to help them 'unlearn' certain concepts, notions, or attitudes which are, for example, believed to be at variance with an integrated view of science. It will also give information on whether the future teachers study science at the elementary level and secondary level, and in what form—was it memory-dominated or inquiry-oriented or descriptive?; was the sciences learned as

only one or more completely separate courses(chemistry, biology, physics) or as integrated science or no science at all was done.

The factor of **relevant technology** covers every thing from standard teaching techniques to the use of satellites for education- and embracing films, slides, computer-assisted instruction, micro-teaching, closed-circuit televisions etc.

The factors of **educational materials** are closely related to the preceding input (relevant technology), in fact there is no clear cut boundary between the two inputs but the term educational materials are used in this case to include materials like books, educational models, laboratory kits etc.

The role and importance of the next factor '**characteristics of the teachers**', particularly looking at the role of the teacher as a 'learning facilitator', are surely self-evident. The teacher as a learning facilitator has the task of helping students in various ways (through dialogue, lecture, questions, demonstration etc.) and also in various settings (classroom, laboratory, lecture hall etc.) to achieve his objectives. A proper design of a course must therefore take careful account of the characteristics of those who will teach it- the level and recency of their training in 'subject matter' and pedagogy, their teaching experience, their attitudes towards students and teaching in general their socio-cultural background etc. The history of educational reform efforts contain many examples of failures traceable to false assumptions either consciously or otherwise, regarding the characteristics of teachers, particularly their willingness and/or ability to adapt to new materials and/or methods. The lack of teacher trainers with the proper attitudes and methods could be a more serious problem for the designer of programmes for the education of teachers of integrated science. For example, will the future teacher of an inquiry-oriented science course learn their science from teachers who exemplify lecture or other out-dated methods?

The factors of '**resources and constraints**' is described by Foecke as a kind of 'miscellaneous category', which, inspite of that , includes so many very important elements which affect the intelligent design of educational programmes but have not yet been mentioned. Of importance to mention as resources/constraints that frequently affect the

educational designs are finance, time, legislature (ranging from laws regarding compulsory school attendance, teaching of certain subjects and forbidding the teaching of certain things). Other sources of constraints are from students, parents, teachers, administrators, ministry officials etc. Many a worthy reform has failed because the innovator failed to take account of the resistance which might come from these sources.

Perhaps it is worth noting here that generally these factors as could be understood from their analysis are closely interwoven and do not necessarily stand out distinctively as separate, unrelated factors as the schematic representation seems to be portraying. There are, in fact, no clear lines of distinctions between most of the factors, rather one only sees the point of representing each factor in the way they have been done for reasons of emphasis and being explicit.

In a more or less specific perspective, Balogun (1983) asserts that there seems to be some general agreement that the preparation of a teacher must include the following:

1. General education or general studies consisting of some basic academic studies.
2. Some study of subject(s) that the student-teacher intends to teach.
3. The professional studies of education which include, *Educational foundations* (philosophy, psychology, sociology, history), *Curriculum studies* (principles of curriculum development, methodologies).
4. Teaching Practice.

Balogun further regrouped these elements into two broad groups: Cognate Studies(1&2), And Professional/educational studies(3&4).

It follows from this that a programme for the preparation of teachers for integrated science teaching should have the following elements:

- Cognate Studies;
- Educational Foundations;
- Pedagogical Studies;
- Teaching Practice and perhaps some ancillary course(s) [Balogun, op cit.].

In Richmond(1974), an international panel refers to these same elements as:

- Cognate areas;
- Theoretical studies;
- Methodological studies; and
- Practical teaching.

The Nigerian National Policy on Education also states that the curriculum of teachers colleges will consists of:

- (a) General studies(basic academic subjects);
- (b) Foundation studies(principles and practice of education);
- (c) Studies related to the students' intended field of teaching;
- (d) Teaching Practice(Fed. Republic of Nigeria, 1981).

However, the general issue relating to these various elements considered to be important in the education of teachers are the questions of how we can justify their inclusion in the curriculum; how we can treat them in relation to one another; what should be the appropriate time application or effort between them and what do they look like in practice, that is, what does a student do and what does a teacher trainer do etc? It is most likely that the practice in relation to these elements in teacher education varies significantly between countries, colleges and even with the specific type of teacher education programmes. These are in fact the key issues that need to be addressed in relation to the education of teachers of integrated science.

5.4 COMPETENC ES FOR INTEGRATED SCIENCE TEACHING.

What desirable competencies or characteristics are expected of an ideal integrated science teacher? His professional and subject discipline competencies - what skills, attitudes, extent of knowledge (contents) and pedagogy are to be considered adequate for

the preparation of a teacher of integrated science? Are these competencies different from those expected and used in the preparation of either a biology, chemistry or physics teacher? Effort will be made to answer these questions in an attempt to provide a theoretical framework of desirable competencies for the education and training of teachers of integrated science.

The Seventh Regional Consultation Meeting on Asia and the Pacific programme of Educational Innovations for Development (APEID), (Bangkok, 1981), while developing the workplan of APEID for its third programming cycle(1982-1986), identified what it called '**Open Competence**' which was defined in the context of science education as referring to "empowering concepts and skills which are flexible and applicable to a wide variety of situations, rather than a limited scope."

'Openness', the Meeting explained, is associated with the ability to transfer experiences from one situation to another and go beyond the boundaries of science while 'Competence' is the ability to perform efficiently in **cognitive, psychomotor, and affective** terms. The perceptions of the 'open competence' by this Consultation Meeting were, inter alia, represented as the:

1. possession of appropriate knowledge, skills and attitudes acquired through science education and the ability to apply these in a wide variety of situations; and
2. ability to synthesise knowledge from different disciplines of science to be able to predict and view the problem of society.

'Open competence' therefore could be viewed from this perspective as a complex and integrated concept encompassing various competencies and attitudes related to problem-solving, processes of information processing, creativity, decision-making etc.(See **Appendix N[c]** for additional details on the open competence).

Sharing from his own personal experience on the subject of desirable characteristics of teachers of integrated science, Showalter(1974), identified three categories of such characteristics desired of an ideal teacher of integrated science and which according to him are crucial to the business of teaching integrated science. These are :-

1. Personal philosophy of science.
2. Personal life and teaching style.
3. Personal knowledge of learners and learning.

The first category, '**personal philosophy of science**', according to Showalter, involves a commitment on the part of the teacher to the concept of the unity of science. He should view the various specialised sciences as arbitrary sub-divisions of the larger sciences. That the 'disintegration' is only apparent and not real but it is of human origin. This is to say, the environment in which we live is of an integrated nature, the living things and non-living things have their own components of science in the form of biology, chemistry, and physics. It is only in the attempts of individuals to understand the complexity of nature and the environment that has led to such systematic analysis and consequent fragmentation of knowledge as we now know science to be. These sub-divisions or specialised sciences, Showalter said, are useful to scientists but the larger general view of science is more useful to all people. From this unified science viewpoint the teacher should acknowledge the existence of certain factors that permeate all the specialised sciences that exist today. Showalter stated that once these factors are acknowledged as the essence of science, it follows logically that they should form the core of liberal education in science for all people. In this context he gave examples of these permeating factors, recapitulating first the seven humanistic values proposed by the Educational Policies Commission of U.S.A. reported in Victor and Learner (Ed),(1972) as values that "characterised the enterprise of science as a whole". They are:-

1. Longing to know and to understand.
2. Questioning all things.
3. Search for data and their meaning.
4. Demand for verification.
5. Respect for logic.
6. Consideration of premise.

7. Consideration of consequences.

Other factors mentioned by Showalter as permeating the sciences are related to the epistemological issue of the unity of the universe such as the idea that every thing in the universe is part of the same universe. In other words, it is seeing nature in the unity with which it presents itself.

Secondly, theories developed to explain the nature and origin of human knowledge typically identifies science separately from other types of human knowledge but do not distinguish between the specialised sciences.

Another factor closely related to the epistemological factors is the set of 'processes' which characterise science but not exclusive to science. These processes which include observing, inferring, classifying, quantifying, controlling variables, predicting, interpreting data, formulating hypotheses, modelling, and defining operationally represent the dynamic aspect of all sciences.

Factors which promote communication among specialised scientists are also seen to permeate the whole of sciences. These factors include the group of invented concepts or constructs that seem to be useful throughout sciences including ideas like equilibrium, model, field, system etc.

Personal life and teaching style- The category of personal life and teaching style demands that the integrated science teacher should reflect the spirit of science in his day-to-day life and above all in his classroom actions. That is the teacher's behaviour in relation to students, colleagues, school administrators, officials and the general public should demonstrate the application of the philosophy of science. In this context, Showalter went on to suggest that if teachers of integrated science are to be successful, they must act so that classroom learning activities are consistent with a unified science philosophy. This means that the teachers must, for example:

1. value students' questioning of all things which must be done always even outside the context of the science class.

2. view their own teaching methods as the application of working hypotheses about teaching which is followed by collection and analysis of data and followed by a modification of the hypotheses.

3. find opportunities to emphasise the application of major principles and concepts in a variety of contexts that use materials from the traditionally separate sciences as vehicles for learning.

4. be more concerned with helping students learn the relatively few major concepts, processes, and values that permeate all sciences than with students acquisition of large number of facts which have limited usefulness in place and time.

Personal knowledge of learner and learning- This third category of competencies, according to Showalter, requires of teachers of integrated science an awareness of the nature of learners and the learning process. This awareness is needed by at least, all teachers of all subjects but Showalter feels that the integrated science teacher needs it more. The proper awareness, he said, would be manifested by the teachers acting as if they believed that:

1. the purpose of a school and curriculum is to help students learn, not to provide a vehicle for the teachers to satisfy their own needs.

2. individuals learn at different rates.

3. individuals learn in different ways and even a given individual may learn in different ways at different times.

4. certain individuals may not be able to learn certain things meaningfully because their present level of cognitive development does not permit it.

5. individuals learn best when they are interested in learning.

As a result of this awareness about the learners, the ideal teacher of integrated science will:-

(a). utilise a broad mixture of teaching methods as opposed to using only one or two methods.

(b). advocate an evolving curriculum that over the years will change in response to the needs and interests of students and society and to improvement in the school's technical equipment.

(c). work cooperatively and actively with colleagues on local and, if possible, on state, national, and international levels to improve science education.

It can be understood from Showalter's position on the teachers' competencies that it requires largely of the science teacher a change in attitude in respect of the nature and spirit of science as well as towards the learner and learning.

During the 1973 Maryland conference on the education of teachers for integrated science, a working group also came up with a number of competencies (see Appendix N[a]) required of a teacher of integrated science (Bajah, 1989). These competencies demand of an integrated science teacher a change in attitude, acquaintance with teaching facilities and some 'minimum' knowledge of science. The question that might arise from this requirement of 'minimum' knowledge of science for a teacher of integrated science is that what amount and nature of science contents should be considered as adequately meeting the 'minimum' requirement. In other words, what is being considered as constituting the 'minimum' standard in science for the teacher of integrated science? Is it possible or not possible to determine such a standard? It is the opinion of this researcher that perhaps, an exposure of the science teacher to the fundamental concepts of the various disciplines of science would be an attempt at meeting the 'minimum' knowledge.

Making a contribution on the education of teachers of integrated science, Cingel and Yoong (1979), emphasised that the special needs required by the teacher of integrated science to enable him perform his responsibility effectively, are associated with his role as a teacher of integrated science. They therefore felt that there is the need to recapitulate on the expected role of the teacher of integrated science. These roles, they believe, are implicit in the characteristics of the integrated science curriculum projects, as they tend to put it succinctly that:

almost every science curriculum project nowadays seems to have the following characteristics: more stress than before on concepts and processes; use of a variety of techniques ranging from the use of audio-visual strategies to techniques of formulating objectives; an influence of

learning theories, e.g. of Bruner, Gagne, Ausubel, Piaget, Vygotsky; application of new teaching techniques and methods in a shift from mainly verbal instruction to the use of several senses; discovery-learning and openness in the teaching-learning situation, and involvement of students in decision-making; more attention to the social relevance of the application of science and to concern for the environment and for man; a trend towards integration either in the use of integrative principles in the separately taught subjects or by integrated *sensu stricto*; and a trend to both individualisation and socialization at the same time.

This wide array of characteristics associated with integrated science curriculum projects would therefore imply that if the teacher of integrated science is to perform his task with interest, confidence and effectiveness, his special training needs must be tailored towards the demand of these outlined curriculum characteristics. On these special needs of the teacher of integrated science, Cingel and Yoong cautioned that, although it is clear from the literature that there has been a great deal of thinking about requirements, guide-lines, objectives etc. and there is no lack of good ideas in general or specific terms about the education of science teachers, the reality of most teacher education does not reflect these views. We should therefore realise that the function of such statements is to generate ideas, to influence people, to serve as guide-lines and not to provide prescriptions.

A working group discussion during the Nijmegen conference, Netherlands, 1978, centred on the development of some desirable attitudes in teachers of integrated science. The outcome of this forum, reported by Cingel and Yoong(1979) can be seen in **appendix N[b]**. Other special competences suggested by this working group as desirable for the teachers of integrated science included training them in skills necessary to make a sensible selection of contents(problems/tasks) which match the skills, interests and abilities of pupils(the contribution of the learning theories and theories of development were though important in this respect) and should be a good manager of resources e.g. be able to recognise the potentials of existing aids.

Discussing the science content background as part of the need issue for the prospective teacher of integrated science, Cingel and Yoong said that the science background for every teacher of integrated science should at least reflect what science really is. They therefore suggested that in the training of teachers, we have to develop the skills and attitudes that can be considered typical for science.

The opinion and suggestion proffered here by Cingel and Yoong appears rather too general to be considered meaningful in giving specific direction to a person in search of a more or less specific guide on what science competence can be considered adequate for a teacher of integrated science. In as much as they are not expected to have gone to the extreme by making prescriptions of what science background an integrated science teacher needs, the making of rather general statements of that kind take us to another extreme. General statements have rarely proved to be very useful especially in situation where specific directions are being sought.

A sub-group at the 1978 Nijmegen conference, in Cingel & Yoong(1979), took a special concern for the issue of science competence for the teacher of integrated science and made the following assumptions that:

1. Teaching fundamental science deals with concepts, models and processes developed by scientists in each discipline; teaching integrated science deals with the unity of the universe and how man interprets what he observes.
2. Traditional university courses produce 'disintegrated' scientists i.e. people who perceive the parts but not the whole; they therefore are not suitably adapted to train teachers of integrated science.
3. Prospective teachers of integrated science in pre-service training should receive training in the basic concepts, models and processes of the various disciplines.
4. Teachers must experience the same problems as pupils in respect of, for example, open-ended problems and decision-making (this point stresses the importance of using with our pre-service teachers the open practical working methods of science in the same way as we want them to be used in the classroom).

The points raised here are that although concepts, models and processes are developed by scientists in each of the science disciplines, the integrated scientist should attempt to interpret these in the context of 'unity in nature'. Single discipline scientists are therefore considered not 'suitably adapted' to train teachers of integrated science as they are seen to have been presented science in a 'disintegrated' form.

Ogunniyi(1983) believes that to be a successful integrated science teacher, one must have a broad background in the basic sciences(physics, chemistry, and biology). This, he said, is necessary to avoid a situation where a teacher teaches only the areas he understands. He added that, to prepare integrated science teachers for their task, a programme of training should be designed to meet both the academic and the professional needs of the teachers. Such a programme, as he puts it, should:

help them to develop certain *abilities, skills and attitudes* e.g. ability to coordinate individual or group activities; ability to stimulate pupils to work independently; ability to use audio-visual aids; safety skills; ability to use texts and the guide effectively; skills in improvisation; ability to ask leading and probing questions; ability for maintaining a peaceful and working atmosphere; ability to creatively use different teaching methods...

These attributes, Ogunniyi believes, will derive from the type of training a teacher has had as well as his awareness of the underlining principles for the integrated science programme which emphasises pupil-centred activities, scientific literacy, application of science and technology at home and at work. Hence he concluded that unless an integrated science teacher is aware of these implications he will not be able to implement the objectives of the programme.

5.5 SUMMARY AND CONCLUSION.

This review has attempted to survey the kind of competences that are considered desirable for the education and training of integrated science teachers to enable them perform their classroom tasks effectively. The goals/objectives for the education of integrated science teachers for the primary, secondary and tertiary levels of education were examined. It seems clear from these objectives that the main target of attainment in the education of integrated science teachers includes:

1. Science content preparation - a broad base background knowledge in the different areas of science disciplines(biology, chemistry, physics, earth sciences etc.), especially of an integrated nature.
2. Professional education (foundations of education, curriculum studies and teaching practice)

3. Competencies in the processes of science, scientific attitudes, creativity and improvisation.

4. Issues of science, technology, environment and society - exploring the relationship between science and technology and their application to the environmental and societal issues.

In context, the concept of competence refers to the integrated science teachers' ability to perform efficiently in the cognitive, psychomotor, and affective domains with respect to science and technology; and their ability to apply the above acquired proficiency (in knowledge, skills & attitudes) to decision-making in problem-solving in their environment (society). In other words, besides acquiring through science education the appropriate knowledge, skills, and attitudes, the teacher of integrated science should in addition have the ability to synthesise such knowledge from the different disciplines of science and apply these in a wide variety of situations as well as be able to predict and view the problems of society. Hence, competencies for the integrated science teachers when viewed from this perspective is a complex and integrated concept encompassing various competencies in knowledge, skills, and attitudes as related to problem-solving, processes of information processing, creativity, and decision-making.

From this review, three things appear clear; firstly, the teacher of integrated science has been portrayed to be a paragon of virtues, needing skills not only those of a teacher but also of a scientist. The skills needed are those of a wide ranging environmental teacher and specialist scientist. Secondly, most authors attempting to discuss the issues of desirable competencies for the science/ integrated science teachers were more concerned with the theoretical specification of the competencies that science/integrated science teachers would require in handling their classroom jobs and what such teachers should be seen to be doing as evidence of having imbibed such competencies. But rarely are such efforts complemented with specifying the processes of how these competencies could be developed in the teachers. Perhaps, the gap is left to individual teacher training programmes to devise their own strategies of how to develop their teachers to attain the target, having known what competencies are needed and the terminal behaviour expected of the teachers. Even so, mention should have been made of simple and basic processes like team-work

and the departmental approach to curriculum development and delivery as a strategy towards encouraging close interaction between the separate sciences. The interaction of chemistry, physics, biology etc. under the science department with the leadership from an overall head of science provides a rich culture not only for integrated science but also the single sciences vis-a-vis the teachers; under the science department, periodic meeting of all science teachers can be organised to discuss teaching methods, educational objectives and organizational matters. In survey of secondary education by the HMI, Department of education and science, 1979, it was observed apparently that science departments were more likely to be well organised if there were leadership from an overall head of science. Whereas in schools where the various science disciplines exist as separate department with their head, had noticeable lack of direction, staff cohesion and unity of purpose in the work.

Thirdly, there was no show of any clear distinction between competencies required by a science teacher from those of an integrated science teacher. Most often authors attempting to, may be, specifically address issues in relation to integrated science teaching (e.g. competencies, the case in point) have invariably tended to sound as if they were addressing the issue of 'science' in general. In which case, the terms 'science' and 'integrated science' have been used inter-changeably in writings as synonyms. For instance, the goals/objectives for the education of integrated science teachers, developed by the 1973 Maryland Conference, was later titled 'Objectives for science teachers education' even when the entire conference was held under the auspices of developing strategies for the education of integrated science teachers. It seems, therefore, that in the context of science education, there is no distinction between a 'science teacher' and an 'integrated science teacher' other than the 'game of words' in interplay in writings. It is clear that no distinction between a science teacher and an integrated science teacher has been made (if any) in this review in relation to desirable competencies, rather, competencies in performing the task of teaching in both cases have been portrayed with a common perception of no difference. There are, however, notable significant differences between competencies desired of the various single science disciplines teachers and those of the science/integrated science teachers. The specific competencies of biology, chemistry and

physics teachers are not reviewed here as they are considered beyond the scope of this work.

However no matter the subject of teaching, it is generally the believe that well qualified teachers are a sine qua non of successful curriculum impementation, and that no curriculum material is teacher proof, hence deliberate effort must be made to familiarise the teachers with the materials they are expected to use in the classroom. In spite of this understanding, most often that not, so many teachers and other decision-makers in Nigeria tend to lag behind in this ideal; rarely are they armed with up-to-date concepts of the aims and the nature of the science curriculum. It is with this in mind that attempt has been made in the next chapter to analys the JSS core curriculum for integrated science and some teacher training curricula for the benefit of the Nigerian integrated science participants.

CHAPTER 6

ANALYSIS OF THE NIGERIAN INTEGRATED SCIENCE CURRICULA.

The guidelines of the Nigeria Integrated Science Project (NISP) curriculum documents do not give a clear enough picture on the nature of integration model used to construct the curriculum that could be of help to the teacher implementing the curriculum. The Curriculum Development Newsletter No. 1 (1970), for instance, explained that integration would be around major concepts of Life, Energy and Matter and provided a flow chart with a network of arrows linking various sub-concepts (see appendix E). It is not clear if such a flow chart is of much help to the teachers without a guide to explain how to interpret and implement it in practical terms. In fact the use of such flow charts as indicators of integration pattern for instructional guidance has been criticised by Jevons (1969) when he wrote:

It is not difficult to draw diagrams showing two key concepts - Matter and Energy - with a lot of lines showing the total inter connectedness of every thing with nearly every thing else. Exercises of this kind are certainly interesting... but how much they help students is debatable. Some of the connections are rather artificial, and in any case teaching cannot be done according to such schemes, since time has one dimension less than a block diagram. A teaching scheme must take the form of a linear sequence...

In spite of such caution from Jevons, the flow- diagram approach (Appendix E) recommended by the curriculum development Newsletter No. 1 (1970) still remains about the only guide to teachers on the integration patterns of the NISP. Moreover, the revision of the original two-year NISP curriculum of 1970 to the new three-year curriculum in 1982 saw a shift from the original conceptual approach of three major concepts (Energy, Life, and Matter) to a thematic approach of six socially appealing themes (see below) as the focus around which the curriculum content would be integrated.

- You as a living thing;
- You and your home;
- Living components of the environment;
- Non-Living components of the environments;
- Saving your energy;
- Controlling the environment.

With the adoption of these six themes and the recommendation (Bajah 1983) that the original flow chart (Appendix E) be used as the map of NISP integration, it would certainly present some difficulty for some teachers in fitting the six themes to the map. Normally, one would have expected that if these six themes are the foci of curriculum organisation, then they ought to be seen as the fulcrums of the integration map; this does not appear to be the case. It is, therefore obvious that these problems will make teachers uncertain as to the nature and pattern of integration to pursue in the course of using the Junior Secondary School (JSS) curriculum. This problem has given rise to calls for further clarification (Olawaju 1983).

This section sets out to contribute to such clarification by analysing not only the JSS core-curriculum for Integrated Science but also the curricula for teacher training at the colleges of education and the universities covered by this study.

The Junior Secondary Schools and Colleges of Education are provided with national core curricula while the universities maintain separate and independently designed curricula.

Attempt has been made by the researcher to analyse these curricula in terms of scope and intensity of integration. As reviewed in chapter 4 of this work (pages 77-79), Blum (1973) defined "scope" of integration as "the range of disciplines and fields of study from which content has been used in an integrated science curriculum". He also defined "intensity" as "the degree to which the subject matter has been truly integrated" or blended.

He then suggested three categories of intensity of integration between disciplines namely, "Coordination", "Combination" and "Amalgamation". According to these categories, a coordinated curriculum was seen as one whereby independent subject programmes were taught simultaneously but under the influence of a common agency such as an educational authority or planning committee. A combined curriculum was described as a science programme in which the chapters or other major units are organised around headings taken from the different disciplines. An amalgamated curriculum was described as one in which an interdisciplinary topic or issue forms the unifying principle at the chapter level.

In the light of the above categorisations Blum (1973) as well as Haggis and Adey (1979) studied and provided evidence about the scope and intensity of integration provided for in a number of science curricula. All the authors noted the difficulties attendant upon trying to provide a detailed analysis of the intensity of integration to satisfy all the intended meanings of integration in a curriculum. For example, Blum, having noted that various curricula integrate content around interdisciplinary issues such as "air", "water", "pollution", "concepts", "processes", and "inquiry", admitted he was unable to represent all these "integration principles" in his intensity of integration matrix, and therefore suggested further publications to deal with these.

6.1 PROCEDURE FOR CURRICULUM ANALYSIS.

In carrying out this analysis effort was made to analyse the curricula in terms of the extent to which they provide for the range of meanings (or principles) of integration as identified earlier in chapter 3 (section 3.3) and chapter 4.

This analysis was considered essential for the following reasons:

- (i) To establish if there is any relationship between the teacher training curricula and that to be implemented in schools;
- (ii) To clarify for the users of the curricula, particularly the teachers and teacher trainers, the provisions that exist therein for integration .

An attempt was made to describe the integration of the several curricula in terms of:-

- (i) Unity of all knowledge;
- (ii) Conceptual unity of the sciences;
- (iii) Processes of enquiry;
- (iv) Social relevance of science;
- (v) Interdisciplinarity (Scope).

To carry out this analysis, an instrument, "Integration Checklist" (appendix F), with a set of criteria generated for this task, was used.

To measure integration in the curriculum in terms of "Unity of all Knowledge", the title (theme) of each unit was taken as the fulcrum around which all knowledge in the unit would be organised. Then, the topics (sub-themes) under each unit were examined for fit, that is, whether or not they fit logically into the range of knowledge expected to appear under such an overall unit theme.

For 'Conceptual Unity', the entire contents of each unit or course were examined to identify any evidence of provision made for the following conceptual schemes and major concepts:-

- Diversity
- Change
- Continuity
- Interaction
- Systems and Organisation
- Cycles
- Energy
- Forces.

As already discussed in chapter 3, sub-section 3.3.2, these conceptual schemes and major concepts are widely regarded as having considerable potentialities for conceptual integration across various science disciplines, and have been employed as such in the development of several integrated science curricula.

Integration as 'Processes of Enquiry' was measured in terms of the following

process/enquiry indicators:-

- Observing**
- Classifying**
- Reporting**
- Organising**
- Generalising**
- Predicting**
- Experimenting**
- Using/Making Models**
- Measuring**
- Problem Solving.**

The selection of these particular enquiry skills was based on the fact that their acquisition is part of the aims of the National Core Curriculum for integrated science (see section 2.1.1 and 2.2). Evidence of provision for developing any of these skills in a given unit/course was regarded as satisfying integration requirements in that respect.

To measure integration as the 'social relevance of science', the contents of each theme were examined for evidence or mention of the application or implication of scientific knowledge and/ or processes for people and their environment.

To measure integration as "an Interdisciplinary Study", the contents of the curriculum will be gone through unit by unit to identify disciplines from which they may have been drawn. This facet of the analysis tallies with what Blum (1973) calls the "Scope" of integration.

Throughout the analysis, units/ courses were used as the basis for indicating the presence or absence of each of the integrating principles examined. This strategy was adopted for the fact that it is not always possible or expected that each classroom activity would demonstrate all expectations of integration. Hence, in order to have a fair view of the provisions for integration in the curriculum it was considered necessary to observe a series of lessons or examine a series of activities of the sort that might ordinarily be contained in a unit or course of printed text.

To facilitate the analysis, a check-list (Appendix F) was developed in which provisions were made for all facets (principles) of integration to be identified in the curricula, as well as corresponding themes and units of the curricula. The curricula examined using this check-list were :-

1. Integrated Science National Core-curriculum for the Junior Secondary School in Nigeria. (Appendix G)
2. Integrated Science National Core-curriculum for Colleges of Education in Nigeria (Appendix H).
3. University of Jos Bachelor of Education (B.Ed.) Integrated Science Curriculum (Appendix I).
4. Ahmadu Bello University, Zaria B.Ed. Integrated Science Curriculum (Appendix J).

After analysing all the curricula and recording the results on the appropriate check-lists, the researcher submitted the check-lists to some experienced integrated science teachers both Nigerian nationals and other nationals, for vetting. These experienced teachers examined the curricula in detail and to see whether or not the researcher's analysis as per the check-lists, provided an accurate or fair representation or judgement of the extent of integration provided for in the curricula. Appropriate adjustments were made where the results show differing opinions, to provide a final check-list on which the resulting discussion was based.

It may be necessary to point out one thing about the manner in which the check-list was operated. It is that once a particular integrating principle, say, the "Classifying" process is found to have been provided for in one activity of a given unit/course, that single occurrence satisfies the requirements of the check-list. Further instances of provisions for "Classifying" in the same unit/course, though appreciated, would not add further information to the check-list as far as "Classifying" is concerned for that unit/course.

6.3 RESULT.

For further details of results outlined in this section, please refer to Appendix F(i) & (ii).

Analysing the JSS curriculum for the concept of integration as "unity of all knowledge" revealed that with the exception of cases shown in Table 6.1, all other topics seem to fit logically into the range of knowledge expected to appear under the overall themes.

Table 6.1: Topics that were considered as 'misfits' under their overall themes.

THEME	TOPIC
Non-Living components of the Environment.	3&14 - Measurement (appearing under year 2 & 3). 7 - Man in space (appearing under year 1 & 3). 13 - Energy (appearing in year 2 & 3).

Table 6.2: Number and Percentage of topics that were considered fit or not so fit under the themes they appear.

THEME	FIT		UNFIT	
	Number	Percentage	Number	Percentage
You as a living thing.	10	100	0	0
You and your home	6	100	0	0
Living components of the environment.	5	100	0	0
Non-living components of the environment.	17	73.9	6	26.1
Saving your energy.	7	100	0	0
Controlling the environment.	8	100	0	0

Incidentally, all those topics which have been questioned for their fitness under the overall themes appear under the same theme - "Non-living components in the environment". "Measurement" which is a skill, a process-based topic is of relevance to both living and non-living things. This is even clear from the contents outlined to be taught under the topic, evidently it is not just an exclusive activity for the non-living components.

So why cage it under the theme 'Non-living components of the environment'?

We cannot certainly pretend that the topic "Man in space" is about non-living things only. Ironically, while the topic is 'man in space', a glance at the contents to be taught under this topic shows no mention of any link with 'man' either.

The topic "Energy" is being questioned under this theme for the fact that it is regarded as a major concept for integrating scientific knowledge and by trying to cage it under a theme like "Non-living components of the environment" does not appear to have much logic.

Generally, when the themes and the topics are analysed, it becomes obvious, as has been observed from the 'not-so-fit' topics, that the theme 'Non-living components of the environment' like its converse, 'Living components of the environment' are reflective of the traditional categorisation of knowledge into biological sciences on one hand and the physical sciences (chemistry/physics) on the other hand. While it will be necessary to suggest here that a sort of reorganisation of the themes and topics may be desirable to encourage a fuller perception of integration as unity of all knowledge (fitness of topics under their themes), it is also recognised too that, it is not possible to attain absolute integration of the science with a possible loss of the subject discipline identity. However, the point that the researcher intends to make by suggesting further reorganisation of themes/topics is that when claims are being made that a curriculum is integrated, it should, as far as possible, be seen to be so. This is particularly important and relevant when themes are made to be the fulcrum for the integration.

Although suggestion for further reorganisation is being made here, it is in no way implying that the integrated science curriculum analysed for the meaning of integration in science in terms of "unity of all knowledge" has been found grossly dissatisfying. The cases for 'misfits' as shown in tables 6.1 and 6.2 are small minority, as the majority of topics (88%) appear to have fitted well under their covering themes (see table 6.2). This means that such topics with their contents are believed to contribute knowledge towards the building of understanding of the kind of knowledge suggested by their respective covering themes. For example, the theme 'You as a living thing' has the following topics spirally

arranged from year one to year three: 'Characteristics of living things', 'characteristics of animals and plants', 'human beings as intelligent animals'. 'know your body', 'feeding' - all to be taught in year one under this theme; those for year two includes 'the functioning of human body' - movement, excretory system, respiratory system, circulatory system, and digestive system; and for year three - ' food storage', 'nervous system' and 'sense organs', 'reproductive system' and 'health'. By accepting all these topics and their contents to fit under the theme 'You as living thing' presupposes that all of them will help the child build a better understanding of himself as a living thing. In the opinion of the researcher, this is a reasonable approach and measure of "integration as unity of all knowledge".

In respect of provisions for integration as "conceptual unity of science", the different themes were examined for the provision of the conceptual schemes/major concepts. The frequency of occurrence of these major concepts/conceptual schemes were examined for their provision within the content of each theme and their frequency across the themes. These frequencies were tallied across the rows and down the columns (see table 6.3).

Table 6.3: Provision for integration as 'Conceptual Unity of Science' through conceptual schemes/major concepts.

THEME	CONCEPTUAL SCHEME/MAJOR CONCEPT.								
	Diversity	Change	continuity	Interaction	System/Organisation	Cycles	Energy	Force	Total Number & Frequency of concepts provided for
You as a living thing	2	2	1	0	3	1	0	0	5(9)
You and your home.	1	0	1	0	0	0	1	0	3(3)
Living components of the environment.	3	0	0	1	0	1	1	0	4(6)
Non-living components of the environment.	0	3	0	1	1	1	4	1	6(11)
Saving your energy.	0	2	0	0	0	0	1	3	3(6)
Controlling the environment.	0	3	0	0	0	1	1	0	3(5)
Total No. of themes and frequency of concepts provided for	3(6)	4(10)	2(2)	2(2)	2(4)	4(4)	5(8)	2(4)	

NB: Figures in brackets are frequencies.

The result shown on this table seems to indicate that while the curriculum shows fair awareness of integration via conceptual scheme/major concept approach, this approach is not where its main emphasis lies. Hence, a part from 'Change', 'Energy', 'Diversity', and Cycles which show significant evidence of provision for in between 3-5 of the six themes with frequencies of between 4-10, all the other concepts show diminishing representation/presence. Similarly, apart from themes 'You as a living thing', 'Living components of the environment' and the 'Non-living components of the environment' which show evidence of provision for 4, 5, and 6 of the eight conceptual schemes/major concepts examined respectively, the remaining show insignificant provision for these conceptual schemes/major concepts. Generally, the provision made in this curriculum for the concept of integration in science via conceptual schemes/major concepts are more implicit. Hence a lot depends on the teachers to be able to recognise such provisions as they implement the curriculum.

Table 6.4: Provision for integration as 'Process of Enquiry' in the JSS curriculum.

THEME	UNIFIED PROCESS OF ENQUIRY										
	Observing	Classifying	Reporting	Organising	Generalising	Predicting	Experimenting	Using/making models	Measuring	Problem solving	Total
You as a living thing.	8	2	5	3	4	1	3	5	0	6	9(37)
You and your home.	2	1	2	2	2	1	2	0	0	3	8(13)
Living components of the environment.	5	4	4	4	4	1	3	0	0	0	7(24)
Non-living components of the environment.	19	3	18	15	14	11	16	2	4	3	10 (105)
Saving your energy.	3	2	4	4	4	4	4	0	2	1	9(28)
Controlling the environment.	5	1	5	4	4	4	3	0	2	7	9(35)
Total	6(42)	6(13)	6(38)	6(32)	6(32)	6(22)	6(31)	2(7)	3(8)	5(20)	

NB: Figure in brackets are frequencies.

Table 6.4 show evidence of provisions for integration as processes of enquiry in science examined across the six themes of the JSS curriculum. Reference can be made to

the details of this check list in appendix F(i).

The results in table 6.4 reveal the following trends. All the ten processes of enquiry showed evidence of being provided for across all the six themes except 'using/making models', 'measuring', and 'problem solving'. The process 'observing' has the highest provision in all the six themes with a frequency of 42 (mean of 7.0) across the six themes. The next process skill most highly provided for is 'Reporting', frequency of 38 (mean of 6.33) followed by 'organising', 'generalising' and 'experimenting', all with frequencies of about 32 and mean of about 5. The process skill least provided for in all the six themes is 'Using/making models'(mean of about 1.2).

The theme 'Non-living components of the environment' provided for all the ten (10) process skills examined in this analysis and also showed an outstanding high frequency of occurrence for each of the processes. The theme 'You as a living thing' show provision for all processes except for one - 'measuring' and so also the themes 'Saving your energy' and 'controlling the environment' provided for all except 'using/making models'. The other two themes: 'You and your home' and 'Living components of the environment' did not provide for 2 ('using/making models' and 'measuring') and 3 ('using/making models', 'measuring' and 'problem solving'), respectively.

The percentage overall mean of about 87% for all the ten process skills in all the six themes combined shows that the Nigerian Integrated science core-curriculum for Junior Secondary school contains considerable provisions for the teaching and learning of process skills.

Analysing the six themes and their topics/contents for integration as the 'social relevance of science', the result (appendix F-i) shows that for the theme 'You as a living thing', seven (7) of its ten topics showed evidence of provision for 'integration as social relevance'; the theme 'You and your home' shows 100% for social relevance in all its six topics covered under the theme; only three (60%) of the five topics under the theme 'living components of the environment' show provision for integration as social relevance. From the twenty three (23) topics of the theme 'Non-living components of the environment' only seven (30.4%) show evidence of provision for integration as social relevance; the themes

'Saving your energy' and 'Controlling your environment' with seven and eight topics coverage respectively, both show 100% provision for integration as social relevance. Except for the theme 'Non-living components of the environment' which shows a very low provision (30) for integration as social relevance, all the other five themes show very high provision (between 60 - 100%) for the integration as the 'social relevance of science'. Putting all the themes together, it means that a mean of about 79% of the topics in the curriculum contained information considered important for the child's better understanding of science and its implication for himself, his home, his environment, his culture as well as his society and country. From this result, it could as well be concluded that one of the great strengths of the integrated science curriculum lies in the "social relevance" perspective of integration.

The analysis of the curriculum for the provision for "integration" as "interdisciplinary study" (scope), showed the details set out in table 6.5 below:-

Table 6.5(a): SPREAD OF DISCIPLINES/FIELDS OF STUDY CONTRIBUTING CONTENTS TO THE SIX THEMES OF THE JSS CURRICULUM.

THEME	DISCIPLINES/FIELDS OF STUDY DRAWN UPON.	PERCENTAGE CONTENT
You as living thing.	Biology	75
	Health science	17
	Chemistry	08
You and your home.	Biology	33
	Health science	20
	Chemistry	07
	Agricultural science	07
	Physics	13
	Technology	13
	Socio-cultural	7
Living components of the environment.	Biology	56
	Chemistry	22
	Earth science	11
	Agricultural science	11
Non-living components of the environment.	Biology	06
	Chemistry	50
	Physics	26
	Earth science	09
	Technology	09
Saving Your energy.	Agricultural science	23
	Technology	38
	Physics	39
Controlling the environment	Agricultural science	38
	Technology	25
	Physics	06
	Biology	19
	Chemistry	06
	Earth science	06

Table 6.5(b): Scope of Integration in JSS Integrated Science Core Curriculum

SCOPE (Range of disciplines and fields of study drawn upon).	Number of topics/sub-topics	Percentage
Biology	27	27.6
Chemistry	22	22.5
Physics	16	16.3
Agricultural science	06	06.1
Earth sciences (geography, geology, astronomy)	07	07.1
Health science	09	09.2
Technological sciences (incl. environmental sc)	11	11.2
TOTAL	98	100

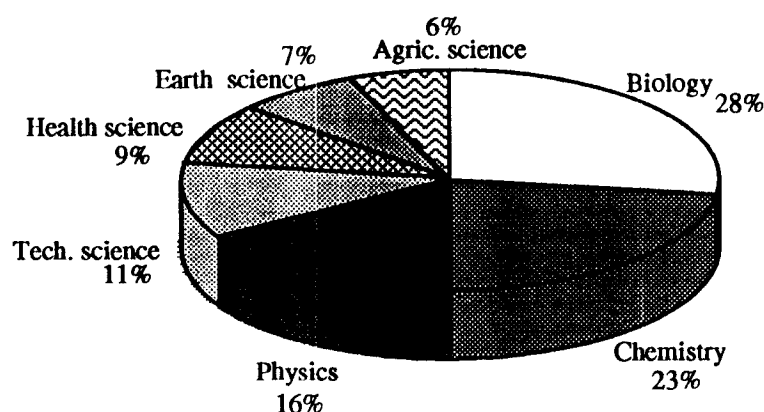


Figure 6.1: Chart Showing the Scope of Integration in the JSS Integrated Science Curriculum.

Table 6.5 (a&b) and Figure 6.1 above show the spread of disciplines contributing contents to each of the six themes. While some themes have as few as only three disciplines and/or fields of study (e.g. 'You as a living thing', 'Saving your energy') contributing contents in building them up, others like 'You and your home', 'Non-living components of the environment' have five and seven disciplines and/or fields of study contributing to their contents respectively. The summary in table 6.5 (b) and the pie chart give the picture of the disciplines and fields of study from which subject matter have been drawn upon to build up the entire integrated science core-curriculum.

6.4 SUMMARY AND CONCLUSION.

The analysis of the JSS integrated science curriculum was carried out in order to establish the nature of integration that exist in it. This was done with a focus on the established range of meanings or principles of integration as identified by this research earlier in this work. In practical terms, therefore, the analysis of integration in the curriculum was done in terms of:

- (a) Unity of all knowledge.
- (b) Conceptual unity of the sciences.
- (c) Process of enquiry.
- (d) Social relevance of science.
- (e) Interdisciplinary study.

The analysis in terms of these five group of meanings of integration in science has revealed that there is a considerable and significant attempt to reflect each of them in the Junior Secondary School curriculum. With the exception of integration in terms of the "conceptual unity of science" which has been sparingly used all the other four have been heavily reflected in the design of the curriculum. With regard to scope of integration, the Integration Science showed considerable scope, as it drew its contents from a wide range of disciplines (table 6.5(b) and figure 6.1). Contents were found to have been drawn mainly from biology (28%), chemistry (23%), physics (16%) technological sciences (11%), health science (9%), earth science (7%), and agricultural science (6%).

With this result one may say that the Nigerian integrated science core-curriculum for the junior secondary school is considerably integrated with an intensity of integration which reasonably fits Blum's 'amalgamated' category. Blum defines an amalgamated curriculum as one in which an interdisciplinary topic or issue forms the unifying principle. The JSS curriculum has, in fact, used as its integration principle or fulcrum for integration, some six socially appealing themes, in which the developers have really gone to great lengths to make an 'amalgamated curriculum'. Less emphasis was, however placed on the 'conceptual unity of the sciences' as an integrating principle. We may not be able to

conclude here that this is a weakness or just a bias but could turn to the assertion made by Abah, (1990) suggesting that the possibility that strategies aimed at achieving maximum integration as the 'social relevance of science' may technically repress the chances of achieving greater integration as the 'conceptual unity of the sciences'.

6.5 THE NIGERIA INTEGRATED SCIENCE TEACHER EDUCATION PROJECT (NISTEP): Core Curriculum for Nigeria Certificate of Education.

The traditional three year Nigeria Certificate in Education (NCE) programme was established in the early 1960s to produce "highly qualified, non-graduate teachers" to teach courses at both the primary and junior levels of the secondary schools. The original intent was to use about 66.6% of NCE graduates to strengthen the teaching force of the primary level while the remaining 33.3% was meant to be deployed to teach in the junior secondary schools (Adesina, 1988). Initially, the pattern of training was meant to expose trainees during the first two years to 'A' level courses while the third year was spent on learning pedagogical content. Prospective candidates for careers in the science offered two major teaching subjects such as chemistry and biology, chemistry and mathematics, physics and chemistry, physics and mathematics, etc. with pedagogical courses for the three year period of the course (Obanya 1983).

In 1977, the National Policy on Education was first published and revised (1981). This document modifies the original objective of the NCE programmes and spells out in broad terms the structure of the curriculum of colleges of Education. The policy prescribes that "... the NCE will ultimately become the minimum basic qualification for entry into the teaching profession" (NPE, 1981). This statement implies that NCE Science and other subjects will be the minimum qualification for teaching in the primary school.

With the introduction of integrated science into the junior secondary school curriculum, the teacher needs were responded to by the colleges of education quite slowly. The few colleges that had some form of teacher training for integrated science were only offering it as a minor course. In fact a careful analysis of the science curricula of colleges of Education across the country reveals a variety of patterns and trends (Akinmade 1990). While these curricular trends reflect the broad prescriptions of the NPE, regarding the curriculum of teachers colleges, studies have shown that the traditional NCE graduate is inadequately prepared and hence encounters great difficulty in the teaching of integrated science at the junior secondary school (Jegede 1983;

Akinmade 1988a, 1988b). These findings cast doubt on the adequacy of the traditional NCE curriculum for preparing junior secondary school integrated science teachers.

6.5.1 Integrated Science Teacher Education Project (NISTEP)

The aim of the project was to improve the quality of the compulsory integrated science teaching in the Junior secondary school by 'training the trainers' and developing training materials, both for the pre-service training in the colleges of education and for in-service training (INSET).

The project was to improve the effectiveness of integrated science teaching by developing a programme in the Institute of Education at Ahmadu Bello University, Zaria, (ABU), to train:

- (i) lecturers in the colleges of education to teach integrated science effectively to those studying on the NCE programme;
- (ii) tutors and the science inspectors in the state-based Educational Resource Centres (ERC) to improve and increase the in-service training(INSET) available to practising teachers.

In addition to this programme of 'training the trainers', the ABU Institute of Education was to develop with, and for use in, its affiliated colleges of education a NCE 'Double Major' integrated science programme. The project was also to assist in the development of a Bachelor of Education (BEd) programme in integrated science under the auspices of the faculty of education at ABU.

To enable the institute and faculty of education at ABU to mount these 'training of trainers' and course materials development programme, the project was also to include a training programme for the science staff of the institute/faculty and maintain a link with a technical partner in the UK -Kings' College London. A series of 3 month training visit to the UK was also to be undertaken by COE and ERC staff.

The project funded by the Overseas Development Administration (ODA) was to be a six year development plan (1988/89 - 1993/94), administered by the British Council with Kings' College, London as the technical partner.

6.5.1.1 Mid -Term Review of NISTEP.

A report from the mid-term review of this project undertaken by T. Allsop and P. Towse (1992), did not present an impressive success story. The project was rather observed to be entangled in a number of crisis situation. The review team was not impressed with what it saw happening with the project. The following are among many of the observations made about the project by the team:

- On the siting of the project, they stated: "Many of the difficulties facing NISTEP stem simply from the fact that what was to be a national project located in two centres became, by default, and for all intents and purposes, a regional one based in ABU..."
- On the development of material they said: "The development of the NISTEP materials is fast approaching a state of crisis, too few units have been produced... and too many yet to be produced..."

As urgent measures, they recommended that more effort be put up to overcome the difficulties thought to be associated with siting of the project by restoring to the project a 'truly national flavour'. Secondly, to avoid further cohort of college students having to complete their course without access to any trial NISTEP materials, they called for the rapid completion of some of the units.

Several other useful recommendations relating to staff development and organisation were made towards managing, sustaining and developing the project.

With the emergence of the National Commission for Colleges of Education (NCCE) to oversee the programmes of all Colleges of Education in the country, Core-curricula for all subjects including integrated science were developed as a first step towards unifying the independent programmes of teacher education that existed then. The NISTEP integrated science curriculum was adopted as a core-curriculum for all colleges of education in the country.

6.5.2 Analysis of NISTEP Curriculum

The following objectives were listed as principal to the preparation of teacher of integrated science (NCCE, 1990):

- to enable students gain the concept of the fundamental unity of science;
- to instil in students a commonality of approach to problems of a scientific nature i.e. the scientific method;
- to increase students' understanding of the role and functions of science in everyday life and in the world in which they live;
- to make students well informed and scientifically literate;
- to enable students acquire and demonstrate the intellectual competence and professional skills necessary to the teaching of integrated science in junior secondary schools, as an inquiry based subject, in conformity with the National curriculum;
- to develop in students the ability to impart and encourage in their pupils the spirit of inquiry into living and non-living things in the environment;
- to develop the ability and motivation in students to work and think in an independent manner;
- to enable students carry out scientific investigations emphasising cooperation, development of appropriate scientific processes and skills and improving their written and oral communication skills.

Generally the curriculum document (Appendix H), claim to have been developed based upon the proposals for minimum academic standards for the Nigerian Certificate of Education (NCE) level approved by the National Commission for Colleges of Education (NCCE), shows that science forms the major component (73% [60 credit units]) of the programme in all the three parts of the NCE. Mathematics and Methodology units (5%[4 credit units] and 10%[8 credit units] respectively) form an integral part of the curriculum and are covered in Parts I and II of the course. Teaching Practice (about 12%[10 credit units]) of the course, is undertaken in the third year of the course and stretches over a period of 10 weeks.

All courses in the programme are said to be core, giving a minimum credit requirement for the award of NCE (Integrated science) of 82 course credit unit (including Teaching Practice).

On the science contents of the programme and its delivery, the curriculum document (1991) states that the science in year one is to be seen as a foundation year in the basic science. This is because, given the varied entry qualification of candidates in terms of science contents, a flexible approach is envisaged with a view to bringing all candidates to a common level of familiarity and understanding with the three major areas of science. However, year 2&3 of the course will see an expanding of the content areas of the basic sciences and this is to be done with constant reference to unifying concepts such as *energy, conservation, balance and cycles in nature, particle theory, and fields of study such as health , technology, and ecology*. The document believes that it is this emphasis on the unity of the scientific world view that will make this programme different from a mere combination of topics from physics, chemistry and biology.

The **Processes of science** also form a major focus of the curriculum as is explicit in the following statements:

"Science" is far more than an inert body of knowledge. It is a method of enquiry in to the nature of the environment. This method can be learned by anyone, and a prime aim, of science curriculum must be to provide students with an introduction to this method to allow them to follow their own enquiries (- cognitive and practical aspects). The cognitive aspects include the ability to formulate questions, to identify variables and design experiments, to interpret result, recognise patterns, general hypotheses, draw conclusions and develop theoretical models. The practical skills, include general skills such as the ability to observe and to measure and more specialised skills in handling and use of laboratory apparatus, living materials and chemicals.

The document urged that the application of the science knowledge and concepts contained in the syllabus to the everyday experience of the students and to the technological development of Nigeria, be emphasised throughout. In conclusion it states "it should be taken as mandatory in this syllabus that these elements of processes, skills, and application are to be woven throughout the content matter as often as they can be."

When the curriculum was analysed for the concept of integration as: 'Unity of all knowledge'; 'Conceptual unity'; 'Unified process of enquiry'; 'Social relevance'; and 'Interdisciplinary' (as in checklist appendix F), the following views emerged:

As 'unity of all knowledge' the titles (21) were taken as the themes, then the topics with their contents, appearing under each theme were examined for their logical fitness under their respective course titles (themes). The result of this exercise (appendix Fii) shows that all topics appear to fit logically into the range of knowledge expected to appear under the themes which they have been placed. There are therefore no cases of misplaced topics as the analysis seems to suggest. When this result is compared with that of the Junior secondary school curriculum, in which obvious cases of misfit topics were observed, it might seem reasonable to conclude that the larger the number of themes chosen to form the fulcrum for the integration, the less problems there are in fitting all the fields of knowledge intended to be included in the curriculum. The difference lies in the number of themes used, six compared with twenty one in NISTEP. However, reflecting on Blum's meaning of 'scope and intensity' of integration, particularly his categories of intensity of integration (coordination, combination and amalgamation), the JSS curriculum whose themes are more interdisciplinary, gives a more representative picture of an amalgamated curriculum than that of the NISTEP curriculum. This means there is more integration between disciplines in the JSS curriculum. The themes of the NISTEP curriculum show less of interdisciplinary issues and more of headings or titles taken from the different science/science-related disciplines. For instance, it is easy to tell at a glance that themes like *statics & dynamics; carbon compounds; and transport, control, skeletal system & development in living things*, are titles taken from physics, chemistry and biology respectively. Contents under each of these topics reflect, almost entirely, the subject matter of these disciplines. With this characteristic feature of taking themes or headings from disciplines to form fulcrums for integration, the NISTEP curriculum fits Blum's category of a 'combined curriculum'. This finding is, in fact, not surprising but only goes to confirm how the integration is being done as was gathered from responses from interviews with the Integrated Science Course Coordinators of the teachers' training colleges. From the interviews it was gathered that the various elements of the

curriculum are handled by different science departments with the integrated science dept handling the main job of coordination.

This pattern of 'integration' seems to fit and suit the nature of how the teaching of the course is being handled in the teacher training colleges. Responses to an interview question by the integrated science course Coordinators from all the six colleges of education and the two universities (faculties of education) on how the teaching of the integrated science course were being handled, revealed that, although, integrated science departments exist, the teaching of the course is a cooperation between all the relevant science department in each college. This is done in such a way that all courses with biases in either biology, chemistry, physics etc. are handled by its appropriate department. The Integrated science departments play the role of co-ordinating the participating departments in planning and supervising the delivery of the course.

6.5.2.1 Provision for integration as 'Conceptual unity of science' in the NISTEP curriculum.

Using the Integration checklist (Appendix Fii), the 21 themes and their topics/ contents were examined for any evidence of provision for the eight (8) conceptual schemes/major concepts. Table 6.6 below shows details of the result.

Table 6.6: Provision for integration via conceptual schemes in NISTEP curriculum

THEME	CONCEPTUAL SCHEME/MAJOR CONCEPT.								
	Diversity	Change	continuity	Interaction	System/Org-anisation	Cycles	Energy	Force	Total Number & Frequency of concepts provided for
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	1	0	2	0	2	0	0	3(5)
4	0	0	0	0	0	0	9	1	2(10)
5	1	2	0	0	0	0	1	0	3(4)
6	0	0	0	0	1	1	2	0	3(4)
7	0	2	2	1	5	2	1	0	6(12)
8	0	1	0	0	0	2	0	0	3(3)
9	2	2	1	1	1	1	1	0	7(9)
10	0	0	0	0	0	0	1	4	2(5)
11	0	1	0	0	0	0	2	0	2(3)
12	0	1	1	0	0	0	0	0	2(2)
13	1	0	0	0	1	0	0	0	2(2)
14	1	0	2	0	0	0	1	0	3(4)
15	0	0	1	0	1	1	0	0	3(3)
16	7	0	0	0	0	0	2	0	2(9)
17	0	1	1	1	0	0	1	0	4(4)
18	0	0	1	0	0	0	0	0	1(1)
19	0	0	0	0	0	0	0	0	0
20	0	4	4	4	0	0	3	0	4(15)
21	0	0	0	0	0	0	1	2	2(3)
	5(12)	9(15)	8(12)	5(9)	5(9)	6(9)	12(25)	3(7)	

The result displayed in the table above shows that the NISTEP curriculum, although, should demonstrate awareness for integration through conceptual schemes/major concepts, it did not appear to have done a good job in its attempt to integrate via the conceptual schemes or major concepts. Although it is a stated objective in the preamble to the NISTEP syllabus to make constant reference to unifying concepts such as energy, conservation, balance and cycles in nature etc. very little has been done to reflect this in the design of the curriculum. Perhaps the teacher is left with the rest of the story.

With the exception of the concepts *Energy*, *Change* and *Continuity* which show evidence (between 40-60% [8-12]) of provision for across the 21 themes, all the others show between 10-30% (3-6) provision. When each of the 21 themes was examined for any evidence of provision for the eight (8) concepts, only themes 9, 7, 17 and 20 showed

provision for 50% and above(4-7) of these concepts which formed the basis for this analysis.

This result is quite similar to that of the JSS curriculum (table 6.3) - that is, less emphasis on integration via the unifying concepts even though they seemed to have been recognised as important medium for integration in science. Where attempts were made to provide for integration via the unifying concepts they are not so explicit, hence it would require a resourceful and an above average teacher to recognise their provision as he performs his duty.

6.5.2.2 Provision for integration as 'Process of enquiry' in NISTEP curriculum.

Table 6.7 below gives the details of the analysis of the NISTEP curriculum for the evidence of provisions for integration as processes of enquiry. Reference can be made to appendix F(ii) for details of this analysis.

TABLE 6.7: Integration through 'unified Process of enquiry' in the NISTEP curriculum.

THEME	UNIFIED PROCESS OF ENQUIRY										Total
	Observing	Classifying	Reporting	Organising	Generalising	Predicting	Experimenting	Using/making models	Measuring	Problem solving	
1	0	0	0	0	0	0	0	0	1	8	2(9)
2	1	1	0	0	0	0	0	0	1	1	4(4)
3	2	1	2	2	2	1	2	0	1	2	9(15)
4	5	1	5	1	1	1	4	0	1	2	9(21)
5	2	2	2	0	0	0	2	0	0	0	4(8)
6	4	2	4	4	4	2	4	0	1	0	8(25)
7	1	0	0	0	0	0	0	0	0	0	1(1)
8	1	1	1	0	0	0	1	0	0	0	4(4)
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	5	5	5	5	5	5	5	0	0	0	7(35)
13	0	0	0	0	0	0	0	0	0	0	0
14	1	1	1	1	1	1	1	0	0	0	7(7)
15	1	1	1	1	1	1	1	0	0	0	7(7)
16	5	4	4	5	2	2	4	0	0	0	7(26)
17	0	0	0	0	0	0	0	0	0	6	1(6)
18	0	0	0	0	0	0	0	0	0	1	1(1)
19	0	0	0	0	0	0	0	0	0	0	0
20	3	1	3	2	2	2	3	0	1	0	8(17)
21	0	0	0	0	0	0	0	0	0	0	0
Total	12(31)	11(20)	10(29)	8(21)	8(18)	8(15)	10(27)	0	6(6)	6(20)	

The result of the analysis of the NISTEP curriculum for the provision for integration as 'processes of enquiry' in which ten (10) process skills were used as criteria for the analysis, shows that , of the twenty one (21) themes, six did not show any provision for any of the 10 process skills examined, only eight (8) show reasonable provision for between 7-9 (70-90%) of the ten process skills. The rest of the themes show provision for only between 1-4 (10-40%) processes.

As in the case of the JSS curriculum, the process skill, 'observing' shows the highest provision (about 60%) across the 21 themes followed by 'classifying', reporting' and ' experimenting' in that order. Others show decreasing representation of between 0 - 40%. The process 'using/making models' has been totally ignored in all the themes.

With this result, the NISTEP curriculum could be rated also to contain reasonable provisions for the teaching and learning of process skills comparable to that in the JSS core-curriculum.

Analysing the topics/contents of the twenty-one themes for the provision for the concept of integration as 'social relevance of science', the result (appendix Fii) shows that with the exception of the contents of themes 1, 5 and 20 which show low (less than 50%) provision for social relevance, all the other 18 themes show very high (between 65-100%) provision. Generally, the 109 topics under the 21 themes show that 79 (72%) of the topics (and contents) contained information considered important for the student's better understanding of science and its implication for himself, his home, his environment, his culture as well as his society and country. The NISTEP curriculum, like the JSS curriculum shows a very high provision for integration as 'social relevance'.

Tables 6.8(a&b) below give the picture of the analysis of the NISTEP curriculum for the provision for integration as 'interdisciplinary study' - the dimension Blum (1973) referred to as the 'scope:'

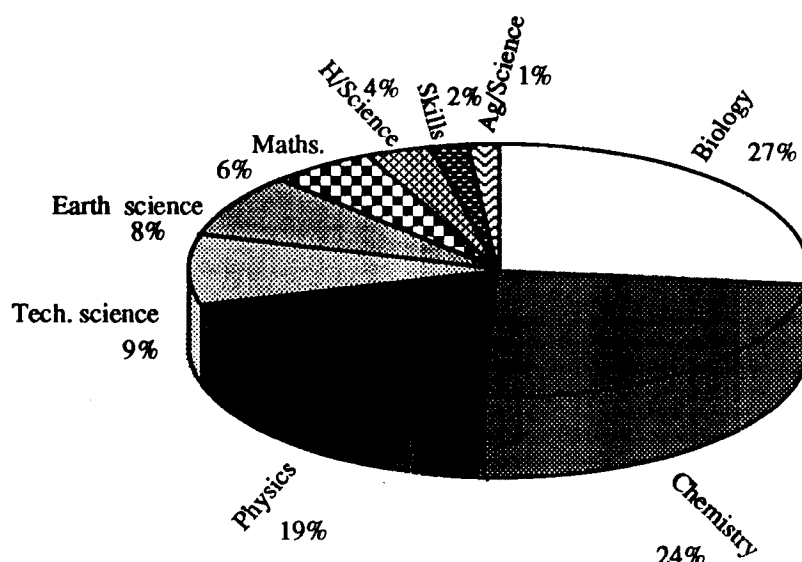
6.5.2.3 Disciplines/Fields of study contributing contents to the NISTEP curriculum:
Table 6.8 (a) gives details of the 'scope' per theme while table 6.8(b) gives a summary of 'scope' for the NISTEP curriculum.

Table 6.8 (a):Disciplines/Fields of study contributing contents to each of the 21 themes of the NISTEP curriculum.

THEME	DISCIPLINES/FIELDS OF STUDY DRAWN UPON.	PERCENTAGE CONTENT
1 Mathematics for Science	Mathematics	100
Introduction to scientific methods.	Biology	25
	Scientific skills	50
	Technological science	25
Components of the environments.	Biology	61
	Earth sciences	20
	Chemistry	09
	Agricultural science	06
	Health science	04
Man and Energy	Physics	73
	Biology	15
	Chemistry	09
	Earth science	03
Nature of matter	Chemistry	100
Processes of Life	Biology	88
	Chemistry	12
Transport, Control, Skeletal system and Development in Living things.	Biology	91
	Physics	03
	Chemistry	03
	Technological science	03
The Earth and the moon	Earth science	100
Man in the environment	Biology	75
	Technological science	25
Statics and Dynamics	Physics	100
Energy and Particles	Physics	83
	Chemistry	17
Metals	Physics	90
	Chemistry	10
The Earth in the universe	Earth science	50
	Technological science	25
	Physics	25
Fundamentals of living things.	Biology	75
	Health science	25
Reproduction and Growth	Biology	100
Carbon compounds	Chemistry	100
Global Ecology	Technological science	72
	Biology	14
	Agric. science	09
	Chemistry	05
Environmental pollution	Biology	50
	Health sciences	25
	Technological science	13
	Earth sciences	12
Science and Society	Technological science	100
Chemical Energetics	Chemistry	83
	Biology	17
Fields and waves	Physics	100

Table 6.8(b): Scope of integration in NISTEP curriculum

SCOPE (Range of disciplines and fields of study drawn upon).	Number of topics/sub-topics	Percentage
Biology	39	27.1
Chemistry	34	24.0
Physics	28	19.4
Technological sciences (incl. environmental sc)	13	9.0
Earth sciences (geography, geology, astronomy)	12	8.0
Mathematics	08	5.6
Health science	05	3.5
Scientific Skills	03	2.0
Agricultural science	02	1.4
TOTAL	144	100.00

**Figure. 6.2: Scope of integration in NISTEP curriculum.**

The analysis of the NISTEP curriculum (tables 6.8 a&b) for the disciplines and fields of study drawn upon has revealed that although themes are used as the fulcrum for the integration, most of the themes do not reflect interdisciplinary coverage but limit themselves to the traditional subject boundaries from which theme was taken. It was therefore no surprise that the analysis (table 6.8a) has revealed that themes 1, 5, 7, 8, 10, 12, 15, 16, 19 and 21 have all their contents reflecting no interdisciplinary integration but are reflecting contents purely drawn from single disciplines. Hence these themes show

their contents to have been drawn purely from mathematics, chemistry, biology, earth science, physics, chemistry, biology, chemistry and physics respectively.

Even themes that appear to have drawn upon more than one discipline in building its contents, tend to draw more heavily on one of the disciplines leaving the others quite insignificant in their contributed contents. For instance theme 4 (Man and Energy) show evidence of drawing its contents from physics, chemistry, biology and earth sciences but the contribution of contents to the theme shows that it drew its contents heavily from physics (73%) while the other three contributed 9, 15, and 3 percentages respectively. Other themes appearing in this way include those of 6, 9, 11, 14, 17 and 20. In fact merely by looking at the themes, it is easy to say from which disciplines it has been taken and one can equally guess what the contents under it would look like. For instance, it will not be difficult to tell at a glance that theme 10, 'Statics and Dynamics' is a topic taken from physics and the contents that will be under it is likely to reflect all or largely physics and so also theme 14, 'fundamentals of living things' gives you a bright clue that all that would be there is biological.

With this characteristic of the NISTEP integrated science curriculum which has been organised around headings (themes) taken from different science disciplines, it fits Blum's category of a "Combined Curriculum", which he defines as 'a science programme in which the units or chapters are organised around headings taken from different disciplines'. The teacher has to do the integrating .

Table 6.8b and figure 6.2 present a summary of the disciplines and fields of study (scope) from which subject matter have been drawn upon to build up the entire NISTEP curriculum. It has drawn its contents from nine (9) disciplines/fields of study; the highest contents from biology (27%), chemistry(24%), Physics (19%) and the remaining six disciplines share 30%.

6.6 THE UNIVERSITY DEGREE PROGRAMMES FOR TEACHERS OF INTEGRATED SCIENCE.

The two universities chosen for this study offer degree courses for teachers of integrated science. Both courses have the general aims of training integrated science teachers for the Junior secondary schools.

(i). UNIVERSITY G.

The curriculum document (Appendix I) of this university states that the primary motivation for the university evolving a training programme for teachers of integrated science was the "lack of truly integrated science specialists to teach the programme in schools" (M.L.Ango, 1991). This situation, the document further stressed, was aggravated with the introduction of the new 6-3-3-4 system of education in the country, and integrated science, besides extending it to the primary schools, was made a compulsory core subject in the 3-year junior secondary schools in the country. This curriculum document, believes that there are numerous problems and challenges in aspects such as 'concept of integration', 'course structure and scope', attitudes to the programme and resources for teaching the course which must be solved to make the teaching of integrated science effective and goal oriented. The document further states:

there is no doubt that the 6-3-3-4 system would suffer much set back if deliberate and concerted efforts are not geared towards production of the needed professional power in both quantity and quality to effectively implement it....the university of 'G', faculties of education, natural sciences and geography department have evolved a new programme for training professional integrated science teachers for the Junior Secondary school level.

6.6.1 The Integrated Science Teacher Training Course Structure of University G

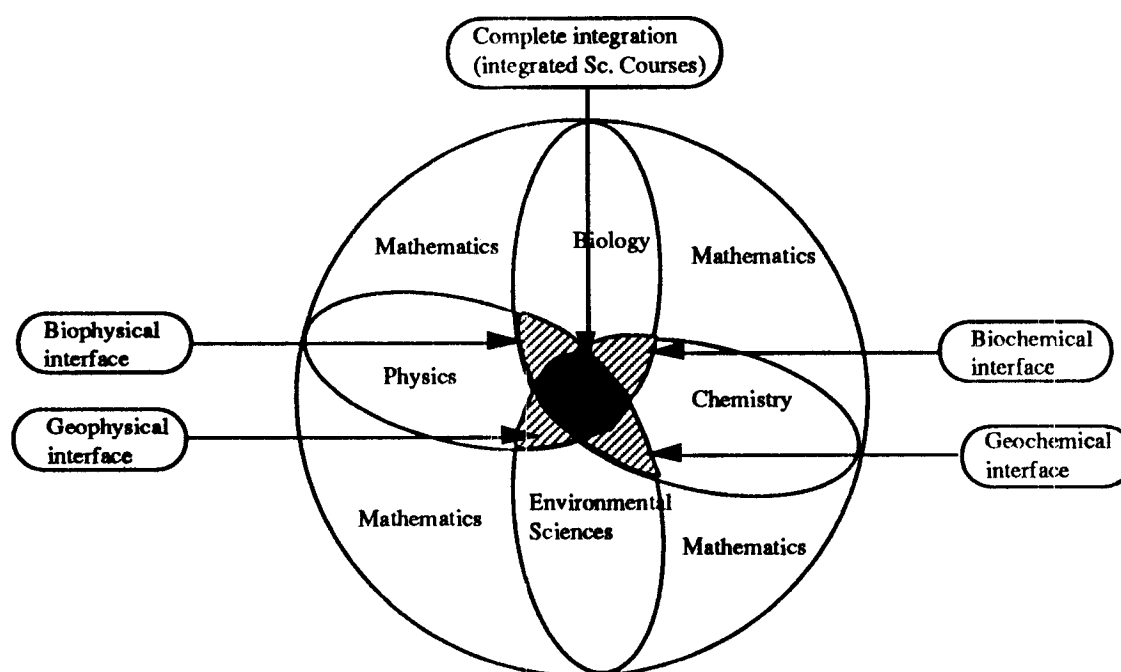
The curriculum document (appendix I) states that the integrated science curriculum and teaching syllabus for the degree programme of the university has been drawn from a careful consideration of the syllabi of all the departments of Science and

Environmental sciences of the university. These include the departments of botany, zoology, chemistry, physics, geography, geology & mining, mathematics and the remedial science. Other integrated science curricula the document claimed to have consulted also, are those of the Junior Secondary School, Nigerian Certificate of Education (NCE) and its counterpart degree programme of University H. The science staff of the faculties of Education and Natural sciences of the University put together the curriculum and the teaching syllabus. A modular approach is said to have been used for the course structuring and organisation. The document describes the course structuring and organisation in the following except:

- a careful selection and determination of concepts, ideas, themes, skills and attitudes that are interrelative in the basic science disciplines as well as applicative for interdisciplinary understanding, nature study and solution of problems. Courses derived in this way are coded "integrated science".
- carefully selected set of ideas, concepts and principles that are basic vital informations and foundations for higher sciences and scientific professions. These courses reflect the basic vital knowledge of life part of nature as exemplified in botany & zoology courses; matter or non-living components of nature as exemplified in chemistry, geography, geosciences and physics; the physical factors or forces influencing life and matter as matter and energy exemplified in physics, geography and chemistry. These courses are to be taught by specialists from the respective science disciplines.
- the course structure takes two facets:
 - an integrated approach aimed at reflecting science as unity but as also several alternatives to problem solving;
 - the second facet presents the pure content (concepts) of science so that the teachers would acquire adequate knowledge on the content of science and the method of teaching the integrated science course.

The document presented the model diagram in Figure 6.3 as depicting the nature of integrated science degree programme of the university. The curriculum claimed to be modular in approach and have been built around the concepts of LIFE, MATTER, and ENERGY. Even with this claim of integration under the themes of Life, matter and energy, there are no evidences of the melding of a wide spectrum of many sciences or otherwise under them, rather each theme maintained the strong traditional subject boundaries. Hence, the theme of 'Life' show a strong collection of subject matter from the biological sciences whereas the themes of 'matter and energy' maintained subject matter from the physical sciences, most particularly chemistry and physics.

Figure 6.3: Model diagram for Integrated Science Programme in University G



(ii). UNIVERSITY H

The curriculum document (Appendix J) of this university states that the degree programme in integrated science trains teachers for integrated science for the Junior Secondary School, and an interview with the course coordinator revealed that the degree programme was a direct offshoot of the Nigeria Integrated Science Teacher Education Project (NISTEP) based also in the institution. The NISTEP has the objective of training teacher trainers for integrated science in Nigeria (see section 6.5.1, page 133). The details of the curriculum document for the university's degree programme in integrated science is in appendix J. The curriculum document, however, did not lay claim to any model of curriculum approach in its development. What this research saw about the pattern of this curriculum is discussed in section 6.7 below.

6.7 SCOPE AND INTENSITY OF INTEGRATION IN THE DEGREE CURRICULA FOR THE TWO UNIVERSITIES (G & H).

The degree curricula for the universities, unlike the spiral curricula (with thematic approaches) for the Junior Secondary School and the Colleges of Education (NISTEP), did not attempt to blend the separate disciplines in the curriculum. With the exception of showing integration in terms of 'interdisciplinary study', and 'the social relevance of science' there are very few strong evidences for integration in terms of 'unity of all knowledge', 'the conceptual unity of sciences' and 'unified process of scientific enquiry'. These were rather given methodological and pedagogical treatments in education •

The scope of integration in both curricula showed a wide choice of disciplines from which contents have been put together to form the integrate science curriculum. Further details are shown in figures 6.4 and 6.5 below.

Table 6.9: Scope of integration in the Integrated Science curriculum for university G.

SCOPE	TOTAL CREDIT UNITS*	PERCENTAGE CREDITS
SCIENCE DISCIPLINES		
1. BIOLOGY	18 (6)	16
2. CHEMISTRY	15 (5)	13
3. PHYSICS	12 (4)	10
4. MATHEMATICS	6 (2)	5
5. GEOGRAPHY	6 (3)	5
6. INTEGRATED SCIENCE (EDSE)	17 (8)	15
7. GEOLOGY	4 (2)	3
EDUCATION COURSES		
8. SCIENCE PEDAGOGIES	6 (3)	5
9. FOUNDATIONAL COURSES	20 (10)	17
10. CURRICULUM COURSES	12 (6)	10
TOTAL CREDITS/COURSES	116	100

(Figures in brackets are the total number of courses)

NB: Integrated Science in this context refers to courses whose contents are interdisciplinary (two or more disciplines), see courses coded IS or EDSE in appendix I or J respectively.

Science Pedagogies includes courses on methodology, skills development and philosophy of integrated science.

Educational Foundation & Curriculum are the general foundational and curriculum courses in education.

* A Credit Unit is defined as one hour of lecture/tutorial time per week for fifteen weeks (one semester), or three hours of laboratory work per week for one semester.

Table 6.10: Scope of integration in the integrated science curriculum for university H.

SCOPE	TOTAL CREDITS/COURSES	PERCENTAGE CREDITS
SCIENCE DISCIPLINES		
1. BIOLOGY	25(13)	20
2. CHEMISTRY	17(9)	14
3. PHYSICS	12(7)	10
4. MATHEMATICS	2(1)	2
5. GEOGRAPHY	5(3)	4
6. INTEGRATED SCIENCE (EDSE)	19(9)	15
7. COMPUTER SCIENCE	2(1)	2
EDUCATION COURSES		
8. SCIENCE PEDAGOGIES	12(6)	10
9. FOUNDATIONAL COURSES	22(11)	18
10. CURRICULUM COURSES	6(3)	5
TOTAL CREDITS/COURSES	122	100

(Figures in brackets are the total number of courses)

NB: Integrated Science in this context refers to courses whose contents are interdisciplinary (two or more disciplines), see courses coded IS or EDSE in appendix I or J respectively.

Science Pedagogies includes courses on methodology, skills development and philosophy of integrated science.

Educational Foundation & Curriculum are the general foundational and curriculum courses in education.

Tables 6.4 and 6.5 show that both universities drew their content materials for their integrated science curricula from a wide range of science disciplines. The contributing disciplines, almost identical for both universities, have 67% credit units drawn from the scientific disciplines and 33% from education. As for the intensity of integration, that is, the degree to which the subject matter of the separate disciplines are blended in the curriculum, it is easily identifiable that only about 20% of the science courses show evidence of attempts at true integration in the curriculum. Such courses are coded 'integrated science' (IS) or 'science education' (EDSE) -see appendix I & J. About 80% of the courses clearly show the separate units of the disciplines such that the subject matter of either biology, physics or chemistry can still be identified. Such courses have been so identified by their disciplines and coded as such e.g. PHY, BIO or CHEM etc. Hence by Blum's (1973) levels of intensity of integration, both universities' curricula best fitted the description of 'coordinated' curricula (see section 4.2.2, pages 77-78).

From interviews with the course coordinators in the different universities, it was gathered that the science courses were being delivered by the science departments while the education departments were responsible only for the education courses. Although the general coordination duty for the integrated science training lies with the education departments they seem to have little control on what go on in the science departments. For instance, when a request was made by the researcher for the details of the teaching curriculum showing itemised details of the experiences the integrated science student teachers go through in each course, such details on the science courses were not available with the coordinator of one the universities. The reason being that such details for the science courses have not been made available by the responsible science departments. This therefore made it impossible to see the actual detailed contents of the science courses being taught as the integrated science programme in that particular university. This phenomenon may have a negative implication for the training programme and the students. There is likely to be no consistency in the delivery of the courses as well as the student experiencing too little or too much in terms of the relevance and depth of content coverage. Perhaps, it is with this fear in mind that the 1978 Nijmegen conference made the assertion that traditional university courses produce 'disintegrated' scientists (Cingel and Yoong, 1979), that is, people who perceive the parts but not the whole. The conference believed that prospective teachers of integrated science in pre-service training should receive training in the basic concepts, models and processes of the various disciplines. It was, therefore felt that professional scientists may not be "suitably adapted to train teachers of integrated science" (Cingel and Yoong Op cit).

CHAPTER 7

METHODOLOGY OF DATA COLLECTION.

The reviews of the meaning of integrated science (chapter 3), the model for its curriculum (chapter 4), the competencies expected of an integrated science teacher (chapter 5) and the analysis of the integrated science curricula in chapter 6 provided the background understanding and the theoretical framework for the field study. It was particularly useful in the design of the tool for data collection and analysis.

This chapter tells the story of the research design and the data collection procedure. It covers the method of data collection, the research population/sample, the data collection instruments used and the description/justification for the data analysis procedures adopted.

The purpose of the research is to explore the strategies being used in training teachers of integrated science in Nigeria, with the aim to:

- i. Gain information about the course structure;
- ii. Find out participants views of the training;
- iii. See how the course aims match the delivery and compare with students perception; and
- iv. Gain understanding of teachers, students and trainers views of integrated science as a school subject.

The field exercise employed the questionnaire as the major tool for data collection. Interviews were also conducted with some of the respondents. Data was obtain only from institutions involved with teacher training for integrated science teaching. Restrictions of time and finance, exacerbated by political and social unrest in the country meant that samples from universities, colleges and schools only from the northern block of the country were possible. Details of sample universities and the affiliate colleges of education which are involved with teacher training for integrated science teaching are carried in table 7.1.

The main questions of the study includes:

- (a) What are the main characteristics features of the integrated science teacher training programmes in the teacher training institutions in Nigeria;
- (b) What are the integration patterns portrayed in the teacher training curricula and the junior secondary school curriculum; is there any relationship?
- (c) How is the concept of 'integrated science' understood by all participants, that is, the classroom teachers, students teachers and the teacher trainers?
- (d) How do the same participants perceive ways integrated science might be effectively taught and learnt in schools?
- (e) How do these participants see their training programme in terms of relevance and usefulness in meeting the needs of integrated science teaching in schools in Nigeria?

7.1 STUDY TRAVEL

The data collection was undertaken in Nigeria between November, 1992 - April 1993. The data collection period was jeopardised by a series of interruptions caused by some political crisis and unrest in the country causing inevitable disruption to the educational system and civil service. Initially, when the researcher had fully concluded plans to leave United Kingdom to Nigeria for the field work in July, 1992, the plan had to be delayed until November (almost four months later). This was because, by July 1992, all higher institutions (universities/colleges) in Nigeria had been closed down when the lecturers embarked on a national strike. They were protesting against the prevailing poor learning condition as well as the unfavourable conditions of service in the universities and other institutions of learning in the country.

The field work journey to Nigeria was finally made in November, 1992 when the strike action was suspended by the lecturers.

While in Nigeria beginning data collection, first from the universities and their affiliate colleges of education, the primary and secondary school teachers went on strike. They were also demanding improvement in their condition of service similar to that

agreed for the higher education institutions. The researcher was again trapped in this crisis posing another obstruction to obtaining data from practising teachers of integrated science in the secondary schools in Plateau state. This strike came shortly before the Christmas break and continued afterwards. The whole States civil service in the country then joined the secondary and primary schools teachers demanding a review of their salary. Work in the country was generally paralysed both in the offices and schools and travel and communication seriously hampered.

In the midst of this seeming confusion, data were being collected at the higher education institutions as they were less affected by this present strike. Consequent upon this seeming crisis in the country, coupled with time and financial constraints , data collection was restricted to the following Northern universities (and their affiliate Colleges of Education) known to be principally involved with the training of teachers for integrated science teaching in the country.

Table 7.1 - Sample Universities and Colleges

UNIVERSITY	AFFILIATE COLLEGES	LOCATION
University of Jos (Plateau State)	1. Federal College of Education, Pankshin.	Plateau State.
	2. College of Education, Katsina Ala.	Benue State.
	3. College of Education, Akwanga.	Plateau State.
Ahmadu Bello University, Zaria (Kaduna State)	1. Federal College of Education, Zaria.	Kaduna State.
	2. College of Education, Gindiri.	Plateau State.
	3. College of Education, Ankpa.	Kogi State.

By mid February, 1993 data collection from the universities and their affiliate colleges had been completed except for those whose students were out on a three months (12 weeks) teaching practice.

At this time the primary and secondary school teachers were still on strike i.e. not in school. I could not wait until the strike was over and so went ahead meeting my respondents (teachers) in their residences at school accommodation or privately. This was not an easy process, it was slow, time consuming, costly and indeed frustrating.

Nevertheless, the respondents reception and responses to my mission were quite encouraging.

The data collection from the secondary schools was about half way through when the strike was eventually called off. This was by the first week of March, 1993. This resumption was important to me as the data collection process became much quicker and easier than it has been. I did in fact obtain the rest of my data from my secondary school respondents with a lot of ease as they were met more readily in their school grounds, administered the questionnaires and had them back almost immediately. By mid April, '93 data collection from the secondary schools had been completed. I had to leave Nigeria for the United Kingdom at the end of April so as not to exceed the six months leave permitted for my field work. As a result of the unavoidable time constraint, the questionnaire administration to some of the student respondents who could not be reached because of their teaching practice engagements, were not carried out by the researcher. The remaining responsibility was ably carried out by a colleague from the University of Jos. There was every confidence that he did a good job in the handling of these questionnaires having assisted the researcher with the data collection prior to taking up this latter responsibility.

7.2 POPULATION AND SAMPLE.

The research population is made up of integrated science teacher trainers, course coordinators and the trainees (both full and part time) in Nigerian Universities and Colleges of Education where certificate programmes are being run for integrated science teacher education. Practising teachers of integrated science in secondary schools in Plateau State also constituted part of the research population.

In choosing the research sample and determining the manner in which the sample was drawn, two factors were influential. First, that the institution has been running a training programme for teachers of integrated science (degree or non-degree, full or part time) for at least five consecutive years. Second, the limitation of time and finance which was exclusively responsible for limiting the field work data collection to the Northern

part of Nigeria. While the university of Jos is located in the middle belt of Nigeria, Ahmadu Bello University, Zaria is in the far North of the country. Similarly their affiliate colleges of education are spread within the middle belt and far North of the country.

The sample population of respondents included the integrated science course co-ordinators in the different institutions, the teacher trainers, student teachers (only the final year) and the practising teachers in secondary schools. The selection of sample schools from which the practising teachers were obtained was done by a method similar to that of stratified random sampling. However, in this case, the schools were first of all sorted into three categories: Government, Voluntary Agency and Private Schools. The random selection of the sample schools then proceeded based upon this grouping relative to their numerical ratios to one another; and on consideration of other such significant variables as, whether the school is co-educational or single sex, special science school or comprehensive, urban, sub-urban or rural in location. The accessibility of a school by road suitable for cars was also an important factor.

The tables 7.2 - 7.4 below gives details of the sample of universities, their affiliate colleges of education and the secondary schools, including the number of respondents and questionnaire return rate.

Table 7.2 - Sample of Integrated Science Student Teachers

NAME OF TRAINING INSTITUTION	No. of Student teachers	Questionnaire return rate
A	10	09 (90)
B	15	15 (100)
C	26	22 (85)
D	20	16 (80)
E	39	34 (87)
F	23	19 (83)
G	23	20 (87)
H	16	09 (56)
TOTAL	172	144 (84)

Table 7.3 - Sample of Teacher Trainers in Universities and Colleges

NAME OF TRAINING INSTITUTION	No. of Teacher Trainers	Questionnaire return rate
A	12	10 (83)
B	10	10 (100)
C	06	06 (100)
D	10	09 (90)
E	04	04 (100)
F	07	05 (71)
G	15	10 (67)
H	08	06 (75)
TOTAL	72	60 (83)

Table 7.4 - Sample of Integrated Science Practising Teachers.

SCHOOL	TYPE OF SCHOOL/LOCATION	I.S. Trs.	R E S P O N S E S
A	State Govt (Mixed) - Rural	2	2
B	Fed. Govt (single-girls) - Sub-urban	2	1
C	State Govt (Mixed) - Rural	2	2
D	Federal Govt (Mixed) - Urban	2	2
E	State Govt (Mixed) - Urban	2	2
F	Voluntary Agency(Mixed) - Rural	2	2
G	Volunt. Agency(Mixed) - Rural	2	2
H	State Govt (Mixed) - Sub-urban	2	1
I	State Govt(Single-boys) - Sub-urban	3	3
J	Private (Mixed) - Rural	2	2
K	State Govt (Mixed) - Urban	2	1
L	State Govt (Mixed) - Rural	3	3
M	V/Agency(Single-girls) - Rural	2	1
N	V/Agency(Single-boys) - Rural	2	2
O	V/Agency (Mixed) - Sub-urban	2	2
P	State Govt (Mixed) - Urban	2	2
Q	State Govt (Mixed) - Sub-urban	2	2
R	State Govt(Single-boys) - Sub-urban	5	5
S	State Govt (Mixed) - Sub-urban	2	1
T	State Govt (Mixed) - Rural	3	2
U	Private (Mixed) - sub-urban	2	2
V	State Govt (Mixed) - Sub-urban	2	2
W	State Govt (Mixed) - Sub-urban	2	1
X	State Govt(Single-girls) - Sub-urban	4	4
Y	Voluntary Agency(Mixed) - Urban	3	3
TOTAL		59	52

7.3 REPRESENTATIVENESS OF SAMPLE

It is probably fair to state here again that the limitation of time and finance exacerbated by the political and social unrest largely influenced the data collection exercise, affecting particularly the numbers and type of institutions visited. Consequently, for the purpose of the data collection, the traditional division of the country into North and South was used. Data was obtained only from Northern Nigeria. Notwithstanding this difficulty, the samples of institutions and respondents were representative of the population from which they were drawn. Although there are over twenty universities in the country, only about ten (10) are known to be involved with teacher training in integrated science. However, only five of this number were known to have relatively older reputations of running the integrated science teacher training courses. These includes the Ahmadu Bello University, Zaria, University of Jos, University of Ilorin (all from the North), University of Nigeria, Nsukka and the Lagos State University (from the South). All except the Lagos State University are Federal Government owned universities. In terms of establishment, the Ahmadu Bello University, Zaria (North) and University of Nigeria, Nsukka (South) are first generation universities (1960s), while those of Jos and Ilorin (both North) are second generation (1970s) and Lagos State University is of the third generation (1980s).

The choice of Ahmadu Bello University, Zaria and the University of Jos and their affiliate colleges of education as the sample universities from which data were collected can be justified to be a fair representation of the others for the following points of view (representativeness here is defined in the context of the universities involved with teacher training in integrated science in the country) :-

(a) Admissions into all universities in Nigeria is controlled by a central board (Joint Admission and Matriculation Board). The admission policy, besides the basic qualification of the candidates, also reflects strongly on the federal character, that is, reflecting upon the geo-political, ethnic and religious diversity in the country. Thus the students in these two universities are fairly representative.

(b) All universities in the country are under the management of a board - the National University Commission (NUC). The commission is responsible for the formulation of policies for running the universities and provide the curriculum for minimum standards in all courses in the universities. Hence, the design of the integrated science curriculum for teacher training, both in content and practice, in the University of Jos and ABU, Zaria were expected to reflect a fair representation of those of Ilorin, Nsukka and Lagos universities.

(c). The two universities, (ABU, Zaria and UniJos), are not only representative but are also suitable choice for this research having pioneered teacher training in integrated science in the country. ABU in particular hosts a pioneering project, the Nigerian Integrated Science Teacher Education Project (NISTEP). Being relatively older and experienced in running the teacher training programme in integrated science, the two universities have higher students population for the course and enjoy wide patronage in student admission across the country for the integrated science teacher training course.

Although the sampling from a population has a disadvantage that not every one in the population has a chance of being included in the sample which in the end may reflect only the views of those chosen, nonetheless, it has the advantage that each constituency is generally represented in the sample. Ross, (1978) and Bailey, (1982) see the advantage of using samples of a population as reducing costs, offering greater accuracy due to closer supervision of data gathering procedure, and greater speed in data collection and analysis. Fox, (1969) maintains that the sample size is far less important than sample representative and that no data are sounder than the representatives of sample from which they were obtained, no matter how large the sample.

7.4 METHODS OF DATA COLLECTION.

In a survey such as this, where a diversity of information is sought, a battery of instruments is needed so that each should supplement the other in order to generate more adequate and meaningful data. Lin, (1978) believes that, to obtain precise and

generalizable data, the 'multi-method' approach to data collection is most desirable because the more the multi-method differ, the more the confidence a researcher has in the found relationship. Although Lin's position here might be referring to the application of different methods on any one group of respondents in an attempt to find a solution to a problem, this study on the other hand has applied a common method to different groups of respondents whose opinions were being sought towards a solution to a problem. The different instruments, though with a common structure, administered to the different groups of respondents has the same target of collecting their various perspectives on the problem.

The following questionnaires designed with a common structure and an interview method were employed for the collection of data:

- (1). Integrated Science Course Co-ordinators Questionnaire.
- (2). Teacher Trainers Questionnaire.
- (3). Student Teachers Questionnaire.
- (4). Practising Teachers Questionnaire.
- (5). Interviews (mainly with Course Co-ordinators).

Besides responding to the questionnaire, all the course co-ordinators in the universities and colleges visited were interviewed. The interview was considered most appropriate and convenient for use because of their relatively small number(one per institution) and only a detailed and close interaction at that level would bring out their views more clearly about the kind of information being sought. Interviews with student teachers and practising teachers in secondary schools were also carried out after the questionnaire administration. The interview was conducted randomly on the students and teachers using questions similar to those on the questionnaire. The aim here was to establish if there is any consistency between what they said and their questionnaire responses. This procedure gave me confidence and reliance on the data collected through the questionnaire; the interview were consistent with the responses from the questionnaire. Further clarification of the students' responses were sought by interviewing the candidates. In other words the survey is to some extent validated by the interview where answers are checked and reasons for the answers emerge. However, both the questionnaire and the interview are

known to have disadvantages. A questionnaire, for example, can be rigid and inflexible. Respondents often tend to give responses which they perceive to be socially acceptable. In addition, there is always the probability of extreme biases emerging with the respondents who might avoid answering some questions fearing at times the repercussion of any criticism made by them. The interview method, on the other hand, has the disadvantage of biased responses that could result from the interviewer's personal characteristics (e.g. facial expression), his form of references and type of leading questions he/she adopts. Nonetheless, the interview method has the advantage of being flexible and suitable for deeper probing of issues involved in a survey. For example, if a question is not clear, it can be rephrased. Besides, an interviewer can observe both what the respondent says and how it is said, as well as probing for additional information if the need arises. The disadvantages of the use of questionnaires and interviews notwithstanding, Dunham and Smith, (1979) stressed the need to combine both tools in data collection when they wrote:

"the unique strengths and weaknesses of both interview and questionnaires suggest that a combination of the two techniques provides the most effective organisational survey programme".

It is due to the wisdom implied in this recommendation that interviews and questionnaire were used simultaneously in this research.

The survey method was considered suitable for this study because it enables one to collect data from a sample and more so that it is possible to generalise from the results of a sample to the population from which it is drawn (Ndagi, 1984). A survey method, which is a type of descriptive study, is primarily concerned with portraying a status-quo of the phenomenon or problem being researched into; describing currently existing conditions and opinions held. Cohen and Marion, (1985) seems to support this point when they gave various purposes of survey as:

- (i). Describing the nature of existing conditions;
- (ii). Identifying standards against which existing conditions can be compared;
- (iii). Determining the relationship that exists between the specific events.

Hence, the survey method was considered most suitable for a study of this type.

7.5 INSTRUMENTATION

As noted above, the research tools for collecting data in this study were the questionnaires and interviews. The questionnaires were the principal instruments.

Due to the fact that no study of this nature has been undertaken, no standardised instruments existed that could have been adopted for use in the work. Consequently, the research instruments used for data collection were all novel and designed by the researcher. However, two steps were taken in order to validate the instruments; first, they were given to some Nigerian science education experts who were also experienced science teacher educators. They were on short term post-doctoral fellowship programmes at King's College, University of London and one other on a special Educational assignment with the Commonwealth Secretariat in London. A pilot study and validation of the Teacher Trainers Questionnaire and the Student Teachers Questionnaire were carried out by a team of 20 Nigerian integrated science teacher trainers at King's College. These teacher trainers had been selected from different Colleges of Education in Nigeria and brought to King's College for a three months training for integrated science teaching under the Nigerian Integrated Science Teacher Education Programme (NISTEP). This team being similar to the actual research population, it was thought to be most appropriate and suitable not only for the validation exercise but served also for a pilot study using the Teacher Trainers Questionnaire.

7.6 PILOT STUDY

Arrangement for the pilot study with the team of Nigerian science educators was made with the Centre for Educational studies, King's College, University of London where they were undergoing an integrated science course. The pilot exercise served the purpose of validating both the questionnaires for the teacher trainers and the student teachers.

7.6.1 Questionnaire administration:

Because of the tight nature of the training course time table at King's College, an inadequate amount of time was available to allow the teachers complete the questionnaires as well as hold a discussion immediately after the exercise. Consequently, with the assistance of their course co-ordinator, the questionnaires were filled in advance and time was ^{fixed} for the return of the completed questionnaires and for discussion of their experiences with and response to the questionnaire. The instructions which accompanied the questionnaire requested the respondents to advise the author on the following aspects of the questionnaire:-

1. Length of questionnaire;
2. Ambiguity or clarity of questions;
3. Suitability of questions for teacher trainers in Nigerian colleges and universities;
4. Omissions; and
5. Any other relevant suggestions.

(See Appendix A for details of accompanying instructions).

The discussion session proved quite useful in identifying issues of ambiguity, clarity of statements and omissions. For instance, certain status/ranks (*principal lecturer* and *lecturer III*) peculiar to the colleges of education were omitted in item 5 of the questionnaire and the correction was done appropriately. Secondly they also suggested that the subject '*Nature Study*', a form of integrated science studied at the primary school level, be included among the options listed for question 6. Unfortunately the inclusion of the primary level '*nature study*' would be out of place in this question. The intention of the question was to collect data on the form of integrated science studied by the respondents at the post primary stage. Hence the original question 6 which read:

"Which of these subjects were you taught while at school?",

was modified to read:

"Which of these subjects were you taught during your post primary education?".

Elements of ambiguity and unclear statements were also observed. For instance, the instructions given for items 17-32. The instruction which initially reads:

Please read through each statement carefully and tick the most appropriate response to show your perception of integrated science as well as showing the importance you attached to the item for inclusion in the curriculum for integrated science teacher education programme,

was modified to read: '

Please read through each statement carefully and tick the most appropriate response to show the importance you attached to it as being an essential feature of integrated science and therefore to be included in the curriculum for integrated science teacher education.

Some of the questionnaire items that were initially seen as unclear, were however left unchanged when explanations were given of such statements. Item 32 is one example that became clear on explanation. Having to give explanation on some items of the questionnaire to help make respondents make sense of it , makes a strong case for personal administration of the questionnaire in order to achieve a good response.

Although twenty (20) questionnaires were administered to the pilot group, only seventeen (17) were returned. This group, drawn from seven colleges of education were made up of 14 male trainers and only 3 female trainers. All were university graduates of science and science-related disciplines. None of them held any prior qualification in integrated science. Table 6.5 below gives details of the respondents.

Table 7.5 - Pilot Group

TEACHER	SEX	NAME OF INSTITUTION IN NIGERIA	STATE
PS/TT-10	M	Federal College of Education, Yola	Adamawa state
PS/TT-17	M	College of Education, Hong	Adamawa state
PS/TT-2	M	College of Education, Gumel	Jigawa state
PS/TT-14	M	College of Education, Gumel	Jigawa state
PS/TT-3	M	College of Education(Technical), Dutsin-ma	Katsina state
PS/TT-12	M	College of Education(Technical), Dutsin-ma	Katsina state
PS/TT-16	M	College of Education(Technical), Dutsin-ma	Katsina state
PS/TT-8	F	College of Education, Kano	Kano state
PS/TT-6	M	College of Education, Kano	Kano state
PS/TT-15	F	Federal College of Education, Kano	Kano state
PS/TT-7	M	College of Education, Ankpa	Kogi state
PS/TT-1	M	College of Education, Oro	Kwara state
PS/TT-9	M	Federal College of Education, Kontagora	Niger state
PS/TT-5	M	Federal College of Education, Kontagora	Niger state
PS/TT-13	M	Federal College of Education, Kontagora	Niger state
PS/TT-4	F	College of Education, Minna	Niger state
PS/TT-11	M	College of Education, , Gashua	Yobe state

7.7 THE QUESTIONNAIRES.

The questionnaire designed by the researcher for the purpose of this study consisted of four types, namely:

- (1). Integrated science Course Co-ordinators Questionnaire.
- (2). Teacher Trainers Questionnaire.
- (3). Student Teachers Questionnaire
- (4). Practising Teachers Questionnaire.

These questionnaires, with the exception for that of the Course Co-ordinators, have two main parts. The first part of each questionnaire was designed to elicit the respondents' biographical information such as their institution, sex, age, educational qualification, and experiences. These data obtained here were used to cross analyse the

key questions in the survey so allowing the researcher to have compared and contrasted the findings in different 'cells' of response. The second part, constituted mainly of the key questions, which sought to collect information on the respondents understanding and perception held about the meaning of integrated science and ways it can be taught in schools. The basic assumption underlying this second part was that unless the teacher trainers, student teachers and the practising teachers understand and hold the agreed perception of what integrated science is and why it is in the school curriculum, neither its teaching nor the teacher training programme can be handled meaningfully. For most of the item in this second part of the questionnaire, a five point response rating format of Likert(1932) is adopted. The five responses which the respondents checked includes: Highly Agree, Agree, Neutral, Disagree and Strongly Disagree, as contained in the Student teachers and Practising Teachers Questionnaires. The response scheme Highly Relevant, Relevant, Neutral, Unsuitable and Undecided, were built onto that of the Teacher Trainers Questionnaire (see Appendix C(i)-(iv) for details of questionnaires). NB: The response 'Neutral' is for items that whether included or not in the curriculum, makes no difference to integrated science teacher training while 'Undecided' means the status of the statement could not be decided.

Some questions are open-ended, and were considered by the researcher as appropriate and suitable for obtaining what the respondents might view as appropriate answers (opportunity for self expression), and to allow the respondent to answer adequately, in detail and if possible, to qualify his/her answer. Though open-ended questions do have some disadvantages, such as difficulty in coding, nevertheless, Bradburn and Sudman, (1979) suggest that they are rather consistently superior to close-ended questionnaires especially when threatening issues are being studied as they allow the respondent to express exactly what he/she wants.

7.7.1 The Integrated Science Course co-ordinators' Questionnaire.

This was a questionnaire for Co-ordinators of the integrated science teacher training programme in the training institutions. The coordinators were the heads of the programmes in their institutions believed to be more familiar with the entire training curriculum - its nature and implementation. The questionnaire was designed to answer such questions as, "What is the nature of the training curriculum in terms of its composition (scope & intensity) and emphasis; how was the programme of the training being implemented and opinion on how relevant was the training programme to the task for which the teachers are being trained etc.".

The 23 item questionnaire has 4 sections: Section A sought factual background information about the course; Section B sought information on the basic entry qualifications for the course; Section C sought information on the details of the contents of the curriculum and Section D looked for the rationale for the course (see Appendix C(i) for details).

7.8 INTERVIEW

The interview method as stated earlier was intended to supplement the questionnaires, probing more information or clarifying information from responses to the questionnaire items. The interview questions were more or less of a semi-structured form. The questions (Appendix D), were only designed as guides indicating areas of interest that are to be probed during the interviews. From these main question areas, smaller and precise questions were developed and used with respondents depending on needs and time availability. A written record was kept throughout the conduct of the interviews.

While it was easier to interview all the course coordinators (1 per training institution) it was not possible to interview all other respondents in other groups because of large size. For the student teachers, between 4 to 8 were interviewed, the criterion being elements of consistency on their responses, such that the less consistent the responses appear to be, the more number of respondents were engaged. In the case of

practising teachers, one per school was interviewed out of a pair found in each sample school.

7.9 QUESTIONNAIRE ADMINISTRATION.

For the purpose of enhancing efficiency of measuring instruments, the researcher made letter contacts with the institutions(the authorities concern) visited well in advance. Borg and Gall, (1983), for example, has noted that contacting respondents before administering the test items, has been found in several studies to increase the response rate. The researcher administered most of the questionnaires personally and stayed with the respondents while they responded to them. Although there was the disadvantage of time consumption and increased expenditure when questionnaire^s/were administered personally and staying with the respondents while they complete them, nevertheless, by so doing, the following advantages arise:

- (i). It ensured that the questionnaire reached the respondents and on time.
- (ii). It gave very little opportunity for respondents to collude with each other and thereby 'falsify' their responses.
- (iii). It produced a high percentage of questionnaire return rate.
- (iv). It gave an opportunity for the respondents to obtain clarification for questions about which they had doubts.

7.10 DATA ANALYSIS PROCEDURES.

The analyses procedures normally chosen for the analysing data from any study are influenced by two major factors:

- (i). The type of data obtained from research using specific tools, and
- (ii). The type of research questions being investigated.

The questions asked in the questionnaires were mainly descriptive and associative statements. According to Dyer, (1979) the aim of descriptive questions is to identify the characteristics of an individual, a group, several sub-groups, a system or an object.

Associative questions, he continued, focus on the pattern of the degree of association or covariance between two or more variables.

Descriptive and associative questions allow two main types of statistics to be used (descriptive and Inferential Statistics). Descriptive statistics in this case show the frequency distribution of subjects' responses on every item while inferential statistics provides an idea about whether the patterns described in the sample are likely to apply in the population from which they are drawn.

Because of the type of information being sought and the nature of responses, the qualitative data analysis procedure was thought to be most suitable for analysing the data collected in the course of this research. The qualitative data analysis procedure is thought appropriate for use because the type of questions asked are those which sought the respondents' views, opinions and understanding about integrated science. In some instances, the respondents were asked to provide definite factual data with the aim of establishing a status-quo. It is therefore the opinion of the researcher that, data of this nature can best be made sense of through the qualitative interpretation. The use of charts, tables, percentages and the Systemic Network Analysis were found to be particularly useful and important in bringing out clearer pictures from the data. Bliss, J. et al, 1983, described the Systemic Network Analysis as concerned with reporting results in terms of relatively simple category scheme. It works with defined categories, but it attempts to elaborate those categories to the point where enough of the individual essence of data is preserved and represented. The strategy for elaborating categories uses a notation - derived from systemic linguistics - which sets out category names in a way that shows their interdependencies. It generates network - like structures in which descriptive categories appear linked in a structure which shows, amongst other things, which categories belong within others, which are independent, and which are conditional on the choice of others.

The total questionnaire return was 264, constituting of 144 from the student teacher, 52 from the practising teachers, 60 from the teacher trainers and 8 from the course co-ordinators. These responses together with those obtained through the interview have been analysed in chapters 8, 9, 10 and 11.

CHAPTER 8

DATA ANALYSIS.

This chapter together with chapters 9, 10 and 11 present the analyses of the data obtained by means of questionnaires and interviews from the integrated science course coordinators, practising teachers, student teachers and the teacher trainers. The research was concerned with establishing the practices in pre-service teacher education for integrated science teaching in Nigerian schools, by revealing through the eyes of the participants the characteristics, quality and appropriateness of the training in fitting the teachers to their job of teaching integrated science.

Specifically this study sought to determine:-

- (a) the characteristics of the preservice teacher training;
- (b) the relevance and usefulness of the teacher training programme to the students for their roles in schools, bearing in mind the background of the students entering the programme;
- (c) the concept of integration portrayed in both the integrated science core curriculum for the junior secondary school and the curricula for preservice teacher education.
- (d) the perception of "integration in science" in schools held by school teachers, student teachers and the teacher trainers; to compare and contrast their views.

Data were sought to answer the following guiding questions:

1. What are the main *characteristic features*¹ of the integrated science teacher training programmes in the teacher training institutions in Nigeria?
2. What is the *integration pattern*² portrayed in the teacher training curricula and the junior secondary school curriculum; is there any relationship?

¹ *Characteristic features*: the total training experiences (contents, pedagogies etc.) of the integrated science student teachers in a training institution.

² *Integration pattern* : the range of disciplines and the manner in which the subject matter drawn from these disciplines have been arranged (integrated) in the curriculum.

3. How is the concept of 'integrated science' understood by all participants, i.e. the classroom teachers, student teachers and the teacher trainers.
4. How do the same participants perceive ways integrated science might be effectively taught and learnt in schools?
5. How do these participants see their training programme in terms of relevance and usefulness in meeting the needs of integrated science teaching in schools?

8.1 CHARACTERISTIC FEATURES OF THE INTEGRATED SCIENCE TEACHER EDUCATION IN NIGERIA.

The questionnaire and interview responses from the integrated science Course Coordinators in the sampled institutions for teacher training, provided the necessary data to address this issue.

The Course Coordinators Questionnaire and the interview with them were intended to collect information on the nature of the integrated science teacher training programme in each institution. Details being sought included admission requirement, design of the course (curriculum), staffing and course delivery. Contrasting features of the training of single subject teachers in science were also sought.

Furthermore, the analyses of the teacher training curricula for both the colleges of education and the universities in chapter six (pp135-150) provided additional information about the importance of different elements of that programme towards producing the integrated science teachers.

Table 8.1 SOME BASIC INFORMATION ABOUT THE TRAINING INSTITUTIONS.

Institution	Training and Certification *	Entry Requirements.	Number in training during 1992/1993	Number of graduates b/w 1988 - 1992.	Target destination for graduates.
A	NCE (both full and part time training).	minimum of five credits(in SSC/GCE), three of which must be in sciences. No interview in the process of selection.	65 (21 FT) (44 PT)	11	Primary and Junior Secondary
B	NCE (both full and part time training).	Credit passes in bio, chem, phy and a pass in maths. Oral interviews testing general knowledge in science are used in final selection exercise.	76 (36 FT) (40 PT)	13	Primary and Junior Secondary
C	NCE (both full and part time training).	minimum of 3credits and 2passes with at least 2 credits in sciences from SSC, GCE, WASC* or Grade II. Interviews are used for final selection.	186 (82 FT) (104 PT)	170 (88 - 04) (89 - 10) (90 - 40) (91 - 52) (92 - 64)	Primary and Junior Secondary
D	NCE (both full and part time training).	Minimum of 2credit passes in any two sciences and pass in English language and maths at SSC, GCE, or Grade II. No interview at any stage.	67 (35 FT) (32 PT)	08	Junior Secondary.
E	NCE (full time training only).	In addition to passing an exam. set by the JAMB*, candidates must pass at credit level in at least two in the sciences. Passes in maths and English language are also require.	93 (FT only)	79 (89 = 15) (90 = 24) (91 = 26) (92 = 14)	Primary and Junior Secondary
F	NCE (full time training only).	minimum of 3credits and 2passes with at least 2 credits in sciences from SSC, GCE, WASC or Grade II. Interviews are used for final selection.	32 (FT only)	09	Junior Secondary.
G	BSc Ed.(part time training)	5 O/L credits in sciences including Maths and English language in addition to at least two 'A' level passes (NCE or LJMB*) in those sciences	127 (PT only)	48 (91 - 26) (92 - 22)	Junior Secondary.
H	BEd (both full and part time training).	NCE in Integrated Science with at least 3 O/L credits in sciences and English Language.	87 (FT - 45) (PT - 42)	30 (91 - 14) (92 - 16)	Junior Secondary & College of Education.

*

NCE - Nigeria Certificate of Education.

JAMB - Joint Admission and Matriculation Examination.

SSC - Senior School Certificate Examination.

GCE - General Certificate of Education.

WASC - West African School Certificate.

LJMB - Interim Joint Examination Matriculation Board.

FT - Full Time.

PT - Part Time.

Of the sample training Institutions (A-H) shown in the table above, six are colleges of education (A-F), three each affiliated to two universities (G and H). The graduates of the colleges of education are awarded the Nigerian Certificate of Education (NCE), the minimum qualification expected for the teaching profession in Nigeria for primary schools.

In Table 8.1, column 6, it can be seen that the colleges of education and the universities both train their student teachers to qualify for teaching integrated science at the primary and junior secondary school levels (ages 6-12 and 12-14 respectively). Although the training at both the college and university levels are targeted primarily to teaching integrated science at the junior secondary school level, the Course Coordinators at the colleges also did indicate that their graduates will be capable of carrying out effective teaching of integrated science at the primary school level. On the other hand, the university graduates (those gaining BEd) are also expected to handle the training of integrated science teachers at the college of education level. It is disturbing that such ambitious expectations are held for the graduates of both colleges of education and the universities to cope with teaching at other levels for which their training does not specifically provide. This is particularly so when one considers the fact that not only do the syllabuses and school levels differ, the needs of the students also vary significantly with age. One wonders, therefore, how well prepared are these teachers?. The implication is that they might not even be well prepared for their primary role at the junior secondary school level. It is perhaps not surprising that researches into teachers' performance in the teaching of integrated science has poor levels of teaching.

The data on the number of graduate teachers from the training institutions between 1988 and 1992 (column 5 of table 8.1) shows that four 4 of the six colleges of education had their first set of graduates by the 1991/92 academic session. The other two (C and E) have had five and four sets of graduates respectively between the 1988 and 1992. The two universities (G and H) have had two sets each.

Generally, for the five year period (1988-1992) examined by this study, a total of only 368 integrated science teachers have graduated from the six colleges and the two universities, an average of 60 graduates per institution for the 5 year duration. This

number is, in fact, quite low in the face of a very high demand for integrated science teachers. Similarly, the low out-put of integrated science teachers from the training institutions is indicative perhaps of the importance given to the integrated science enterprise by both the students and institutions in Nigeria.

8.1.1 Selection of Candidates For Training.

Table 8.1 (column 3) gives details of the entry requirement of each institution.

For the colleges of education (A-F), the stated minimum admission requirement is that an applicant should possess credit passes in the basic sciences (biology, chemistry, physics) and also in mathematics and English Language. This is either obtained in the Senior School Certificate Examination (SSC), General Certificate of Education Examination (GCE), West African School Certificate Examination (WASC), or the Grade Two Teachers' Certificate Examination. These qualifications are said to be of equal status.

For admission to university course, the applicants require same basic Ordinary Level background in the sciences as well as mathematics and English Language. The applicants, however, require principally, a minimum of two Advanced Level passes in the sciences, preferably with grades A, B, or C. These qualifications are obtained either at the Nigerian Certificate of Education examination, General Certificate of Education examination or from other recognised national or international examination boards.

Selection and admission to the courses is largely by qualification and review of application form. Only three (B, C and F) of the six colleges of education use interview methods. Neither of the two universities interview their candidates.

Considering the background of the candidates, as dictated by these admission standards, those entering the colleges of education possess a more uniform entry background than those for university. That is, all are admitted with a similar background in the O/Level sciences and normally they would not have had any initial teacher training for integrated science teaching. Most of these college candidates are practising primary school teachers. On the other hand, candidates admitted into the universities for degree

training for integrated science teaching have varied Advanced Level backgrounds. For instance, the two universities in the study, in particular, specified that the categories of students admitted for their programmes are, in addition to the basic qualification, holders of the Nigerian Certificate of Education (NCE) in integrated science or any two science subjects combination (e.g. Chemistry/Biology; Physics/Chemistry; Mathematics/Physics etc.) and holders of other Advanced Level qualifications in a least two sciences from any recognised examination board (e.g. A/Level GCE; IJMB etc.). The university candidates, however, are usually teachers who would have been teaching at the secondary school level.

All the institutions offer both full-time and part time training for integrated science teaching except for the institutions E and F, which offer full time only; institution G has a part time programme only. While the full time training programmes at both the colleges of education and the universities last for a minimum of three academic sessions, the part time studies are spread over a period of five years with at least one contact session of 8-12 weeks in each academic year.

From the information given on the entry background of candidates for training at the colleges of education, it is obvious that, as far as the teaching of integrated science is concerned, they go through a **pre-service training** (initial teacher training for integrated science). Although their counterparts admitted for the degree programme in the universities have varied entry background, there is no difference or variation in their training package. However, based on these differences on the student teachers' entry background and the mode of study (i.e. full or part time), this research, technically, recognises three categories of training in operation at the university levels:

- (i) **Pre-Service Training** - this relates to full time and part time students who are having initial teacher training for integrated science teaching.
- (ii) **Further Training** - this relates to full time students who have had pre-degree initial teacher training for integrated science teaching and now in the university for degree qualification.

(iii) **In-service Training** - this relates to part time students who have had pre-degree initial teacher training for integrated science teaching and while remaining fully in the teaching service, attend summer break degree programme. It is further training on part time basis.

8.1.2 Training Package For Teachers of Integrated Science.

The questionnaire and interview with the Course Coordinators sought to collect information on what, in real terms, the integrated science teacher trainees for secondary go through, or are being exposed to, in the course of their training.

Table 8.2 below is a summary of the curricular components of the integrated science course. The table shows details of:-

1. the range of scientific disciplines and other scientific fields including mathematics, constituting the science component of the integrated science course;
2. the relative distribution of **credit units** across the integrated science components.

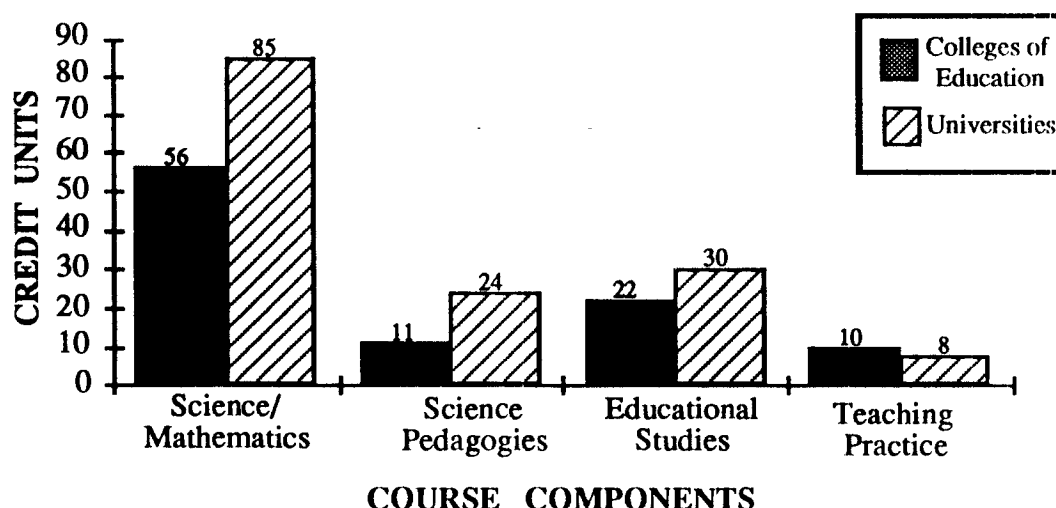
Table 8.2: Components and distribution of credit units in the integrated science curricula.

Institution	Constituents of Int. Sc. course (Scientific disciplines/fields of study and Mathematics)	Credit units/Hours allocated to each of the following curriculum components.				Total credit units.
		Science	Science Pedagogies	Educational Studies	Teaching practice.	
A	Chem, Phy, Bio, Earth sciences, Environmental sciences, maths , Health Science, Science & Technology.	60	10	22	10	102
B	Chem, Phy, Bio, Earth sciences, Environmental sciences, maths , Health Science, Science & Technology.	60	10	20	10	100
C	Chem, Phy, Bio, Earth sciences, Environmental sciences, maths , Health Science, Science & Technology.	60	10	22	10	102
D	Chem, Phy, Bio, Earth sciences, Environmental sciences, maths , Health Science, Science & Technology.	58	12	21	10	101
E	Chem, Phy, Bio, Earth sciences, Environmental sciences, maths , Health Science, Science & Technology.	56	10	20	10	96
F	Chem, Phy, Bio, Earth sciences, Environmental sciences, maths , Health Science, Science & Technology.	58	14	23	10	105
G	Chem, Phy, Bio, Earth sciences, Maths, Environmental sciences, maths and computer science.	92	20	28	06	146
H	Chem, Phy, Bio, Earth sciences, maths, Environmental sciences.	78	27	31	09	145

The specification of the scientific constituents of the integrated science courses by the course coordinators of each institution as shown in column 2 of table 8.2 above reveals that all their curricula were basically developed from a substantial synthesis of content materials from the core science disciplines of chemistry, physics and biology. This finding closely agrees with the result of the analysis of the colleges of education curriculum for integrated science; see chapter six of this work. There is also evidence of contents from mathematics, environmental, technological and health sciences. It can be observed that the set of sciences drawn upon, shows a uniform feature for all the integrated science curriculum in the colleges of education (A-F). This trend is not surprising since all colleges of education in the country are operating a core curriculum

for all subjects including integrated science. Furthermore, it can be noted from the table that the total credit units for the whole period of training in the colleges range between 56-60 for the science and mathematics component, 10-14 for the science pedagogies, 20-22 for educational foundation courses and 10 for teaching practice exercise. These give percentage average credit units of 58%, 11%, 21%, and 10% respectively. For the universities (G and H), the average credit units distribution across the course components are 85(58%), 24(16%), 30(21%), and 8(5%) respectively. Both averages for the colleges and universities have been represented comparatively in figure 8.1 below.

Figure. 8.1: Distribution of credit units across the integrated science teacher education course components.



The credit units for a course or any curriculum component normally gives a quantitative picture of the amount of work load involved in such a course relative to others. The credit unit in turn goes to determine the instructional time allocation, in credit hours, to a course per week, per academic session. The instructional time allocation is done in such a way that the higher the credit units a course has, the more the share of instructional time it takes per week, per academic year. The time allocation is not an arbitrary operation, but is based on a balanced consideration of the quantity of the subject matter to be taught and the cognitive demand of a course.

From the table 8.2, it can be seen that science pedagogies and teaching practice components of the integrated science curriculum for the colleges of education, with credit units of about ten each, take about one sixth ($\frac{1}{6}$) as much time as the scientific and mathematics components take, while the educational foundation courses take one third ($\frac{1}{3}$) of such amount of time. This is to say, the scientific component takes about 60% of the instructional time within the duration of the training, while the educational studies/pedagogies and the teaching practice components take 30 and 10 percent respectively. The ten credit units of the teaching practice, however, represents a minimum of 10 weeks (one academic term) period of teaching practice by the student teachers at the secondary schools with supervision from their trainers. Such classroom supervision during the teaching practice exercise should not be less than three times for each trainee.

Comparing the integrated science course components between those of the colleges of education and the university degree programmes, the table 8.2 shows that both the scientific and the educational components for the university programmes carry higher credit work loads than those of the colleges, i.e. there is a greater content load at university than at the colleges. The university student teachers, however, spend less time on teaching practice; about a maximum of six weeks compared to the minimum ten weeks for the colleges. More importance is attached it appears to students spending time on theoretical knowledge than on the teaching practice.

Table 8.3: Assessment of Integrated Science Staff Strength by the Course Coordinators.

Institution	Number of staff Trainers.	Number with science qualification.	Number of professional science educators	Is your Staff strength adequate
A	4	4	4	No
B	8	8	3	No
C	7	7	3	Yes
D	12	12	6	Yes
E	4	4	4	No
F	7	7	6	No
G	19	19	6	Yes
H	17	17	5	Yes

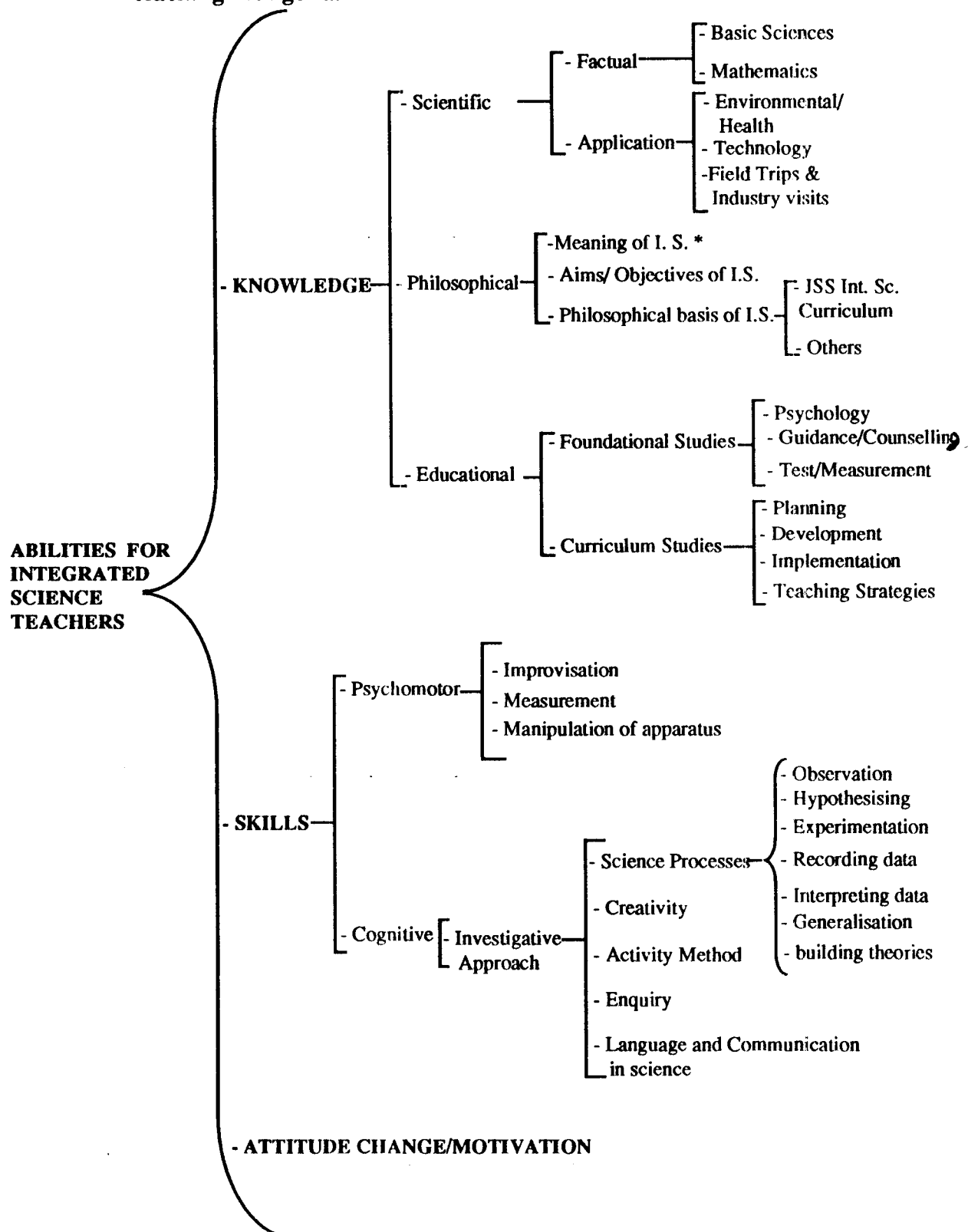
The Course Coordinators assessment of the position of their staff strength in meeting the demand of the training programmes in their institutions (see table 8.3 above), shows that while two of the six colleges of education (A-F) indicated they have adequately qualified teacher trainers, the others described their staff strength as inadequate. The two universities (G and H), on the other hand, show a high number of staff trainers (19 and 17 respectively), but few are professional science educators. Thus, just six out of the nineteen teacher trainers in University G and five out of the seventeen in university H, hold professional qualifications in science teacher education. For the purpose of this research, the term, "professional science educators" referred to persons who hold qualifications in any science disciplines or fields and also in education. Despite this, the university Course Coordinators indicated in interview that their integrated science teacher training programmes were adequately staffed. The adequacy of staffing was interpreted by the course coordinators in terms of the number of staff available to manage the teaching of the courses in the syllabus, not necessarily in terms of quality and quantity of the staff. The course coordinators, certainly, did not consider the adequacy of their staff in terms of staff-student ratio or the professional suitability of the staff for the unique training needs of the course. For, in general practice, higher institutions (colleges and universities) in Nigeria today no longer consider the staff-student ratio an important issue in their admission policy. Hence, for most courses in higher education institutions, the student to staff ratios are uncomfortably high.

In an attempt to understand the sorts of abilities or competencies expected to be acquired by the student teachers in the course of their training which will fit them for their job of teaching integrated science in schools, the items 18-20 of the questionnaire requested the course coordinators to list only three of such abilities as well as any feature(s) of their training considered important in developing skills for integrated science teaching.

The responses to these questionnaire items and the follow up interview of the Course Coordinators revealed a strong consensus on a number of abilities and skills intended to be developed in their trainees. The network (Fig. 8.2) below gives a summary

of the characteristics of the training that goes on in both the colleges of education and universities.

Figure 8.2: Characteristics of training and skill development for integrated science teaching in Nigeria.



* I.S. - Integrated Science

Characteristically, all the integrated science training programmes in the teacher training institutions are intended to train for **KNOWLEDGE, SKILLS, and ATTITUDE CHANGE/MOTIVATION**.

For **Knowledge** acquisition by the student trainees, the Course Coordinators specified that attempts were being made in their training to equip them with a sufficiently broad-base factual knowledge in the basic sciences and other fields of science study. These were being taught with relevance to their application in technology including environmental and health issues. Field trips and visits to industries were mentioned as forming integral parts of some science courses but that they were rarely, if at all undertaken for reasons of financial and time constraint. Indeed it was observed that the field trip/visit was one important part of the curriculum, which, for most institutions, was not being fulfilled.

The students were also being exposed to the meaning, aims/objectives and the philosophical basis of integrated science. These aspects were particularly integrated with practical attempts to familiarise the student teachers with the contents and philosophy of the Junior Secondary School core-curriculum for integrated science. The JSS core curriculum is indeed, primary to the training of the student teachers.

The **Skills** the student teachers were expected to develop during the training can be grouped into two domains: **Psychomotor** and **Cognitive Skills**. The psychomotor skills includes skills as **improvisation, measurement, and manipulation of apparatus**. In the domain of cognitive skills, the students were being trained to acquire skill and proficiency in investigative approach to science teaching. This covers issues such as the **scientific processes, creativity, activity oriented instruction, enquiry process** and the **art of communication in science**.

Another character of the training programme expressed by the Course Coordinators as important was that of developing in the student teachers intrinsic motivation and change in attitude towards the subject 'integrated science'. This aspect, they said, was particularly important and necessary because of the opinion and attitude held (either erroneously or correctly) towards integrated science by the society and the academic world itself. The general opinion held about it, portrays the subject as a 'soft-

option' science only for the 'never-do-wells' in science and that those who opt for it do not intend to go further into any science career. Secondly, the apathy shown by many universities in the country towards the subject by not offering it, gives students little motivation to apply for the course. The general feeling of fear and threat held by the students is that the field, 'integrated science' has no real future career development but holds only a dead end for its practitioners.

The Course Coordinators, when asked to describe the details of how the teaching of the course contents for the integrated science were being handled in their institutions, revealed largely a common trend in the way the teachings were being done. That is, the lecture method dominated the delivery of the course; different science departments/faculties collaborated to teach the science contents of the course, and the departments/faculties of education handle the educational studies/pedagogies. In the universities, in particular, it is common practice to have the full time integrated science student teachers join their other science disciplines counterparts in their various departments to receive teaching in those relevant science courses. For instance, the integrated science students would move to, say, chemistry, physics or biology department to join the bonafide students of that department to receive same teaching, from the science professionals of that department. Such non-professional teachers, in a majority of cases, have nothing to do with the educational purpose for instruction other than delivering the technical knowledge of their particular disciplines. These phenomena are more common in the universities than occur in the colleges of education.

Although the departments of integrated science exist in each institution, such departments were not necessarily staffed with adequate and relevantly qualified integrated science teacher trainers to run completely and independently the affairs of the teacher training within the department. Rather, the departments are more administrative in function, performing such duties as admission, registration, examination coordination and collation of results, time-tabling and overseeing the general running of the teaching. This feature is also more pronounced in the universities than the colleges.

Even though the teaching of the subject matter of the integrated science course was described as a collaborative venture between the various departments/faculties in an

institution, the teaching practice exercise is not. It is an exclusive business of only qualified science educators, which for lack of qualified staff at the university levels in particular, it deteriorates into an exercise for only a few staff with a consequential gross inefficiency and ineffectiveness. A majority of the teaching staff are only science teachers lacking qualification in education so they are normally not involved in the teaching practice exercise. This leaves only a few staff who have the necessary qualification to oversee the teaching practice exercise but are often overloaded in terms of staff-student ratio resulting in general inefficiency. During the teaching practice, each student teacher is expected to be visited at least three times by at least two different trainers. This was hardly being fulfilled especially in the universities where there were a shortage of professional science educators. In which case the student teachers rarely received sufficient supervision on the teaching practice. Whether a student teacher passes or fails the teaching practice, is determined by averaging the marks awarded by the different supervisors that visited the particular student. The outcome of such failures on the part of the training institution to give the required supervision to the student teachers, was that they were awarded marks almost by default.

8.1.3: Integrated Science Teacher Training Vs. Single Science Teacher Training.

Besides the piece-meal efforts being made to train teachers for integrated science teaching in Nigerian secondary schools, there is normally a larger turn-out of single science subject graduate teachers every year from both the universities and colleges of education. The university faculties/institutes of education as well as the colleges of education in Nigeria have for long seen the business of producing single science subject teachers, among others, as their main pre-occupation. So with the introduction of integrated science into the curriculum for the secondary education, colleges of education and a small proportion of universities in the country have responded to the staffing demand while the majority still drag their feet and some are totally apathetic towards the integrated science programme.

This study, using the Course Coordinators questionnaire and the interview, also sought to establish what the differences are in the training of integrated science and the single science subject teachers. The Course Coordinators were instructed to elaborate such comparison under the areas: CONTENT STUDIES (constituent of the subject matter being taught), PEDAGOGICAL STUDIES (educational studies/science pedagogies), and TEACHING PRACTICE.

The summary of the responses are presented in Table 8.4 below.

Table 8.4: Comparison between the training of integrated science and the single science subject teachers.

Institution	Content studies	Pedagogical Studies.	Teaching Practice.
A	- wide science contents are covered by integrated science students in an integrated way while other students cover contents related to their single disciplines only.	- efforts are made to be as practicable as possible in teaching all aspects of the integrated science course.	- same
B	- more science contents for integrated science students but taught with a deliberate attempt to integrate them thematically.	- same foundational and science pedagogies courses but integrated science students maintain activity based training in most science teaching.	- same
C	- for integrated science students more science disciplines are covered with deliberate effort to de-emphasise the interdisciplinary boundaries.	- more or less the same except that constant attempt is being made to emphasise 'hands on science' for the integrated science students.	- same
D	- integrated science students cover more from the different science disciplines in an integrated fashion.	- activity based instruction especially in the area of science pedagogies.	- same
E	- integrated science course in more broad based covering a wide field of science.	- same	- same
F	- integrated science students cover a wider fields of science though less deep as their single science counterparts.	- in addition to foundational courses the integrated science students enjoy more emphasis on processes and scientific skills.	- same in both cases
G	- more areas of the different science disciplines are covered by integrated science students.	- same in both cases.	- shorter teaching practice period for the integrated science students for lack of time.
H	- integrated science students offer all the major sciences.	- attempt to integrate science knowledge using the conceptual approach.	- no difference

From the above table, it can be understood that there is a difference in the depth and breadth of the subject matter content taught to the two groups of student teachers. The integrated science student teachers are exposed to a wide range of subject matter

from all basic sciences and other science fields of study (interdisciplinary) but with less depth and breadth of coverage from each of the contributory science subjects. The single science student teachers, on the other hand, have their subject matter content largely restricted to the single science discipline. Although the single science student teachers are also exposed to some subsidiary and elective courses from one or two other science subjects, their main stay throughout the training period is on their individual science subject. These areas of specialisation for the single science student teachers are, unlike their integrated science counterparts, studied in greater depth and breadth. In other words, the content studies for the integrated science student teachers show broad interdisciplinary coverage but narrow content involvement while those of single science student teachers show narrow interdisciplinary coverage but an in-depth, broad study of special subject area.

In terms of pedagogical studies, and the teaching practice exercise, what appears obvious from the expressions of the Course Coordinators was that there were no significant differences in the way both groups of student teachers were handled. However, in much of the teaching of the science pedagogies, a deliberate effort is made to tailor the instruction to be relevant to each group's special disciplinary need. So it was a common expression by the Course Coordinators (table 8.3) that, for the integrated science student teachers, more emphases and particular attention are paid on science pedagogies that encourage the meaning and principles of integration in science as well as giving attention to instructional strategies favouring the teaching of science as integrated. This might not necessarily be the same emphases with the single science subject student teachers.

There is no difference in the teaching practice programme as undertaken by the two groups of student teachers. They have same time duration for full time students, lasting a whole term (minimum of 10 weeks) in the colleges of education and about six weeks in the universities. However, the part time student teachers generally spend less time on the teaching practice exercises than their full-time counterparts because they spent less time during their contact sessions in the institutions.

CHAPTER 9

ANALYSIS OF DATA FROM PRACTISING TEACHERS

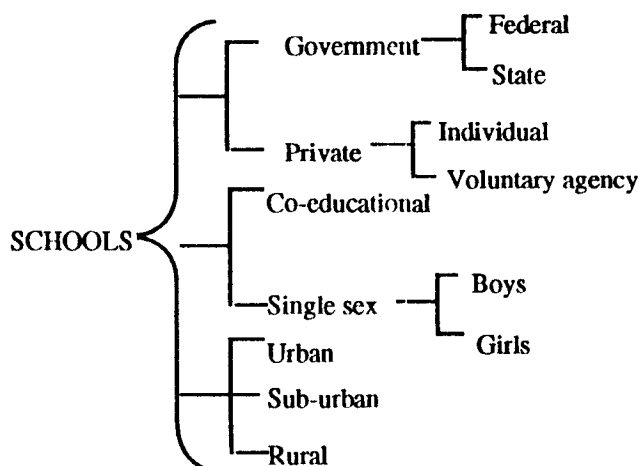
Opinions of classroom teachers of integrated science were sampled on their understanding of and the teaching of integrated science in schools (Appendix Ciii). Fifty two (52) out of fifty eight (58) teachers of integrated science responded to the questionnaire. This represents 90% return rate (see table 7.4, p157). The questionnaire items sought a range of information, including the respondents personal data (e.g. sex, age group, qualification etc.), experiences in the teaching of integrated science, understanding of 'integrated science' and its teaching in schools and an assessment of training received for teaching integrated science.

This aspect of the research was expected to provide valuable information on the classroom teachers' thought about:

- 1- the value of integrated science, the way it was taught, and their own understanding of integration;
- 2- their preparation in terms of knowledge, understanding and training to teach integrated science.

The selection of sample schools took account of the following variables: government or private, urban or rural, co-educational or single sex. (see figure 9.1 below).

Figure. 9.1: Choice of sample schools variables.



The twenty five schools sampled included seventeen (17) government - owned schools (two are federal schools and fifteen owned by the state government), and eight private schools consisting of six owned by voluntary agencies and two by private individuals.

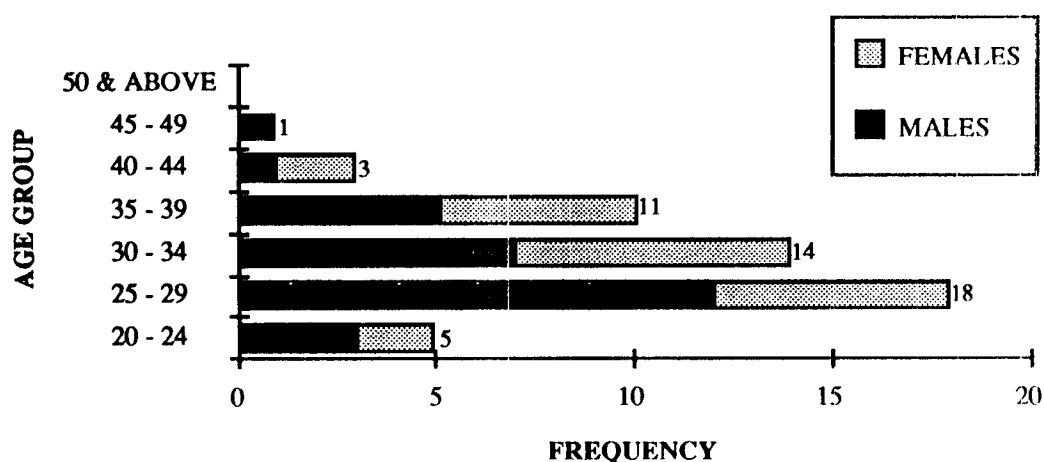
9.1: BACKGROUND INFORMATION OF THE PRACTISING TEACHERS OF INTEGRATED SCIENCE

Section 'A' of the questionnaire sought personal data about the respondents covering variables as sex, age group, academic qualifications/science subjects studied and years of teaching experience.

Some 38% ($\frac{20}{52}$) of the teachers had degrees or their equivalent, the rest, $\frac{32}{52}$ (62%), had the minimum teaching qualification certificate, the Nigerian Certificate of Education (NCE).

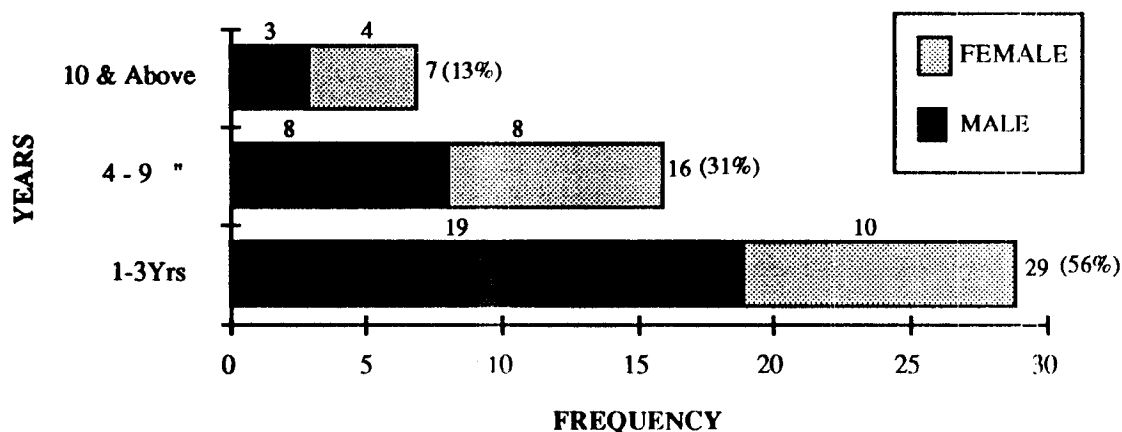
The age profile of the sample is shown in Fig. 8.4 below with details in Appendix L. About 70% ($\frac{37}{52}$) teachers were in their twenties and early thirties while only about 30% (15 teachers) were in their late thirties and above. In fact only about 8% of the teachers were over 40 years. This might be an indication that more experienced teachers tend to leave the job for other employment: teachers generally do not stay long enough in the teaching profession to gain substantial experience. If this is the case, and for whatever reasons teachers do not stay long on their job, there is the urgent need to understand the underlying factors in order to prevent further exodus and the waste of training as well as the apparent use of the teaching ground as a stepping stone to other jobs. Reasons given by some of the teachers on why many teachers tend to leave the profession includes the irregular payment of teachers wages, lack of promotion and motivation as compared to their counterparts in other employments. There is need to instigate policies for the attraction and retention of science teachers, because the teaching profession needs the services of experienced teachers.

Figure. 9.2: Age distribution among Integrated Science teachers.



Teaching experience of the teachers in the sample (fig. 9.3 and Appendix L) show that more than half, about 56% (29) of the teachers are relatively young in the teaching field with experiences of between 1-3 years only. About 31% (16 teachers) have average experiences of between four and eight years while only about 13% (7 teachers) can be rated as having had good teaching experience of ten years and above. All the younger people, age group between 20-34, fall in the categories of the in-experience (1-3 years) and intermediate experience (4-8 years) teachers. In other words about 87% (45 of the 52 teachers) have less than ten years teaching experience and only seven of the teachers (13%) have taught for ten or more years. It is mainly young inexperienced people who are responsible for ^{the} delivery ^{of} integrated science courses in schools.

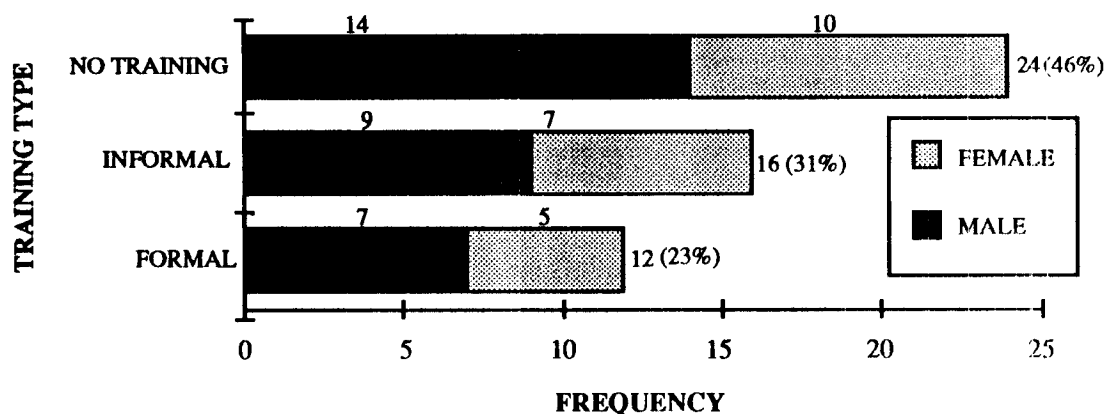
Figure. 9.3: Years of experience among classroom teachers.



The picture revealed here is that only new, inexperienced teachers come into integrated science teaching. Although integrated science has been around for over 15 years and so one cannot expect the availability of well qualified and experienced teachers, it is not the only sole reason accounting for this trend. There is the factor of older teachers in schools who lack the expertise for teaching integrated science and therefore tend to hand it over to new teachers arriving in order to 'escape' from the 'burden'.

Turning now to the form of training received by this sample of teachers, they were asked to state the form of training that qualified them for the teaching of integrated science. The responses are provided in figure 9.4 below and Appendix L.

Figure. 9.4: Training received by teachers of integrated science



From the table and figure above, only 12 teachers (23%) had formal training¹ as integrated science teachers (11 with NCE and only 1 with a degree), 16 (31%) had informal training² for integrated science teaching and 24 (46%) had no training related to the teaching of integrated science. Thus, 77% of the integrated science teacher work force hold no formal training qualification to teach the subject. Almost half of the number of teachers ($\frac{24}{52}$) had no training to teach integrated science.

¹ **Formal Training:** Curriculum-based professional training received in integrated science in an institution leading to the award of a certificate.

² **Informal Training:** In-service training received through seminars, workshops and short term courses for integrated science teaching by teachers who hold qualifications in other disciplines but who teach integrated science in schools.

The questionnaire (item 10) requested the classroom teachers to identify (by selection from a set of reasons) why they were involved with the teaching of integrated science . The result of the teachers' responses are shown in table 9.1 below.

Table 9.1: Why Teachers got involved with the teaching of integrated science.

N = 52

REASONS FOR TEACHING INTEGRATED SCIENCE	TEACHERS' CHOICE: f & %
1. Training and qualification received in integrated science.	12 (23)
2. Motivation from personal interest	05 (10)
3. Assigned to teach it because school lacked trained integrated science teachers.	35 (67)
4. Other reasons (to be specified).	0

Teachers' reasons for their current involvement with teaching integrated science shown above reveals that 35 (67%) of the teachers expressed that they have been marshalled into teaching integrated science for lack of trained specialist teachers. They would not have opted to teach it, if given the chance to make a choice. Only 12 (23%) of them indicated that they were doing the job best suited to their training and qualification, 5 (10%) teachers indicated that, although they were teaching integrated science for the obvious reason of lack of the relevantly qualified personnels, they volunteered to teach the subject motivated by personal interest. This is evident that the integrated science classroom in Nigeria is heavily populated with young, unqualified and unenthusiastic bodies. Surprisingly, the teachers' responses to question eleven of the questionnaire demanding them to indicate either 'Yes' or 'No' to the question "Do you enjoy teaching integrated science?", revealed that 45 (87%) of them answered 'Yes' while only 7 (13%) said 'No'.

However, when asked further (item 12 of the questionnaire) whether they find integrated science more interesting to teach than separate sciences, the following responses emerged: 12 (23%) indicated that integrated science was more interesting to teach than separate sciences; 34 (65%) indicated that separate sciences were more interesting to them than the integrated science they were teaching; and only 6 (12%)

indicated that both subjects have the same level of interest for them. The 12 teachers that indicated preference for teaching integrated science than for the separate sciences were all those who had formal training for teaching integrated science. Of the 34 teachers who made their preference for separate sciences than for integrated science, 12 were from the group of 16 who had informal training for integrated science teaching while the remaining 22 were from the non-trained group. The 6 teachers who indicated that they have about the same interest in the teaching of both integrated and separate sciences were from both informally trained (4) and non-trained groups (2). The interesting contrast between this group of 6 teachers and those in the 'yes' and 'no' groups is that all of them were holders of university degrees and have had more than 5 years of teaching experience in integrated science. That they found the teaching of integrated and the separate sciences equally interesting could possibly be explained by their further education and the long years of teaching integrated science helped in overcoming the difficulties faced by others in the 'no-interest-in-integrated science' group. Despite the fact that there were teachers in this 'no' group who have also had more than five years teaching experience in integrated science, they still indicated preference for the teaching of single sciences than integrated science. Their stance could possibly be explained by the deficient foundation in basic sciences during their early education. This is apparent and characteristic of the type of O/level certificate (the Grade II) they hold. For instance, the teachers numbers 23, 28, 29, 31, 43 & 51 (appendix M) all have been teaching integrated science for not less than five years but indicated that they did not find the teaching of integrated science more interesting than the separate sciences. All of them, except number 23, were holders of the Grade II certificate, an O/Level qualification which, hitherto, did not including the teaching of the basic science but general science. The general science foundation appears not to be the best foundation for the important and demanding job of integrated science teaching.

For teachers with the Grade II foundation, the colleges of education tend to encourage them into taking up further careers in sciences through organising pre-NCE courses in the basic sciences. The pre-NCE courses are usually of one year duration, during which period the candidates receive a rather 'crash programme' teaching on the

basic sciences. At the end of the one year, they are examined internally and successful candidates are co-opted directly into the different science and science-related careers of the NCE programme.

Most, if not all, of the holders of the Grade II certificate go through this route in their pursuit of careers in science. With this kind of loose foundation in the basic sciences, it is not surprising that many find it uncomfortable teaching integrated science and would prefer to teach just one single science.

The teachers were asked to explain their biases, to give reasons why they found integrated science or separate sciences more interesting to teach.

The reasons given by teachers can largely be grouped into two categories: -

- (i) **Curricular difficulties/challenges;** and
- (ii) **Course delivery constraints.**

With respect to the integrated science curriculum, teachers who enjoyed teaching integrated science generally made positive statements about the curriculum; by contrast those who preferred to teach the single science offered mainly negative comments. It was observed that both groups of teachers commonly used the term "broad and interdisciplinary" to describe the integrated science curriculum although in different contexts. For teachers who saw integrated science as less interesting to teach than separate sciences, the use of the term "broad and interdisciplinary" to describe the integrated science curriculum has a negative implication. To such teachers the curriculum's broadness and the way it encompasses other disciplines and fields of study, is over ambitious, too demanding both cognitively and time-wise, for a single teacher to cope effectively with its preparation and teaching. This group of teachers believe that the separate sciences, on the other hand, are less taxing and that unlike integrated science, a person studying a separate science, becomes a master of a definite discipline in depth and breadth. For instance, a comment by one respondent in this respect reads:

..to qualify in a separate science and teach it, is to have mastered such a field in greater depth and not just the learning of bits and pieces from different science fields and yet be a master of 'nothing' as the case is with integrated science.

Teachers who hold more interest for the teaching of integrated science saw the following positive points as the basis for their interest and motivation:

- the 'broad and interdisciplinary' curriculum poses a challenge to the teacher and offers an opportunity, especially for a single science discipline teacher, to broaden his experiences in other scientific fields.
- integrated science offers the most effective way of laying a good broad-base science foundation in children.
- its activity oriented and investigative approach to teaching makes more interesting teaching and learning.
- its emphasis on relevant application to real life situation such as in environmental, health, social and technological issues makes the subject less abstract but interesting to teach and learn.

There are some negative factors expressed by teachers as influencing their lack of interest in desiring to teach integrated science. These are the other group of factors categorised as " **Course delivery constraints**". These factors, recognised by the teachers to militate against the effective delivery of integrated science includes:

- lack of standardly constructed science laboratories;
- where the laboratory structures or improvised rooms are available, they are not reasonably equipped to support effective practical exercises.
- teachers who hold single science qualification accepted they have a natural handicap that constitute a constraint for a comfortable and confident teaching of integrated science all by themselves. That they are often bored and frustrated by unfamiliar topics in the curriculum, especially those that fall outside their science subject of specialisation.

When some of the teachers were further interviewed on why there was such a general negative feeling and low enthusiasm towards the profession of integrated science teaching, it was understood that teachers resent the idea of total confinement to teach only at the junior secondary school level where integrated science is taught at present. This is further aggravated not only by their being looked down upon by their colleagues who teach separate sciences at the senior secondary school level but also the society's general

lack of recognition for integrated science. A comment by one of the respondents on the society's attitude reads:

..in Nigeria today, recognition, respect and dignity are only given to teachers in the teaching profession in the order: primary, junior secondary, senior secondary, colleges of education and universities. How do you expect anybody under this circumstance to feel OK of being confined to the junior secondary school level simply because he has to teach integrated science?.

This social attitude towards the general teaching profession in Nigeria as observed by this teacher reflects also in the manner they are rewarded in their jobs. For instance, the seriousness with which attention is given to educational problems, teachers' wages and other benefits, at the different levels of teachers tend to decrease in the same order with the primary schools receiving the least importance and attention. This attitude, certainly will not motivate any one to engage in a career that is perceived derogatory and less rewarding.

9.2 PRACTISING TEACHERS' DEFINITION OF INTEGRATED SCIENCE

The questionnaire requested the teachers to define 'integrated science' in their own words, assuming that they were defining it to a parent of a pupil who wants to understand what the subject 'integrated science' is all about.

An analysis of the definitions offered by the 52 teachers revealed a range of understanding about the subject of integrated science. The definitions range from very narrow understanding of integrated science as "a subject which teaches the students about scientific process skills to as broad as "a subject which attempts to discover or find out more about the world".

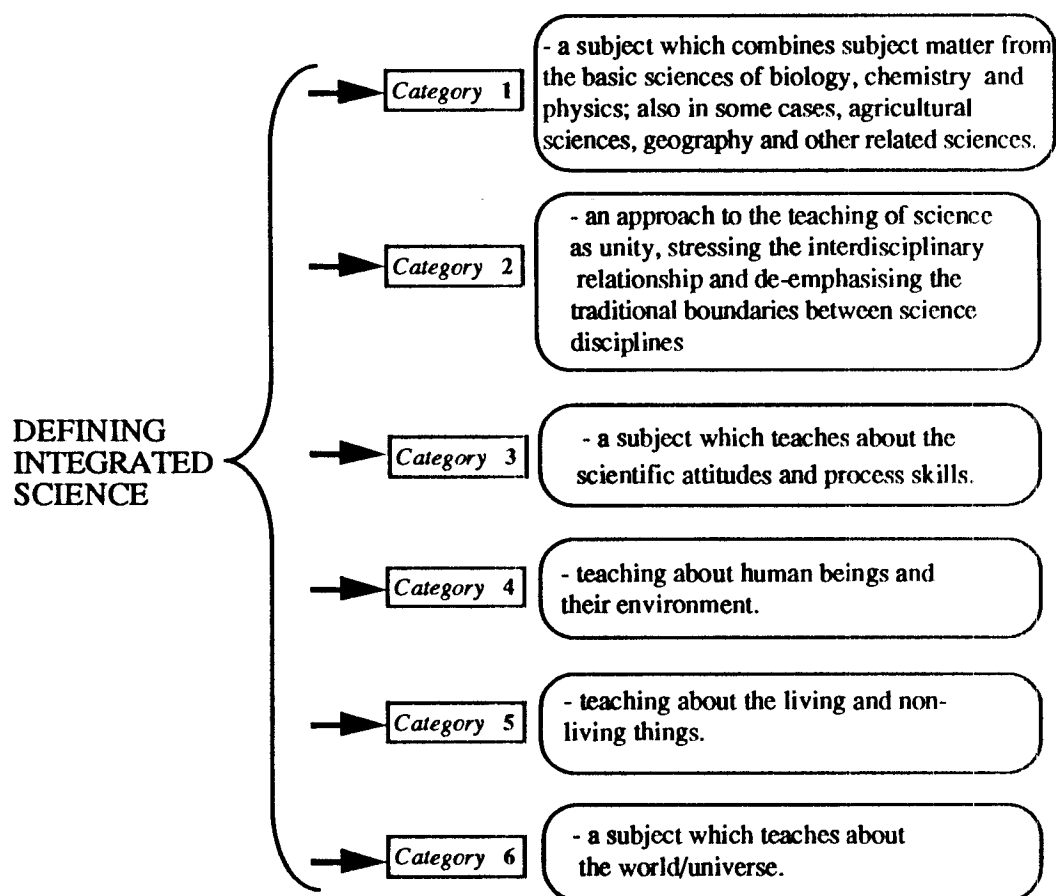
Generally six categories of definitions were identified, though not all with the same level of significant popularity among the respondents (see figure 9.5 page 197). The classroom teachers viewed and defined integrated science from different perspectives. They defined it from the point of view of:

- the science content materials that have been 'integrated' (as is evident in category 1 definition);
- the philosophical view underpinning the teaching of science as 'integrated' in schools (definition in category 2);
- the characterising activities of the scientific enterprise (evident in definition in category 3);
- its interdisciplinary nature (freelance involvement with different subject matter).

This is evident in definitions in categories 4 - 6

Although none of the categories of definitions given by the teachers (figure 9.5 below) can be said to be wrong, none is comprehensive enough to be accepted as representative of the wide range of interests and issues which integrated science teaching is intended to cater for. Such definitions also did not show that the teachers understood very well the concerns of integrated science as portrayed in their national curriculum and in the wider literature.

Figure. 9.5 Categories of integrated science definitions by classroom teachers.



There is a significantly high preponderance of the definition in category 1 (*subject which combines learning materials from biology, chemistry, physics and some other sciences*) among the classroom teachers [43 (83%)], with apparently no difference between those trained and those not trained as integrated science teachers. Twenty six (50%) of the teachers shared the definition in category 2 (*teaching of science as unity, stressing interdisciplinary relationship and de-emphasising the traditional boundaries*) and twenty (38%) of the teachers had their definitions fall within category 3. The remaining definitions in categories 4, 5 and 6 had scanty popularity among the teachers where only 5, 4 and 2 teachers share the same idea respectively. In other words, the popularity of these definitions in category 1 through category 6 diminished in that order; hence category 6 was least popular among the teachers.

It was observed that some of the teachers, perhaps, not confident of defining integrated science in their own words, resorted to copying the integrated science

'descriptors' given in section E of their questionnaire and also from one another. For instance teachers No. 17, 41, 42, had copied definitions from the questionnaire while teachers No. 28 & 29 (from the same school), had identical definitions, which suggests, one would have copied from the other.

The teachers' definitions for integrated science were further examined against the established categories in figure 9.5 to see if there are any relationship or pattern reflected in these definitions. The data showed that seventeen (33%) of the teachers had definitions reflecting only one category (12 in category one; 2 in category 4; and 2 and 1 in categories 5&6 respectively). Eighteen (35%) of the teachers offered definitions that spanned two of the six categories, and fifteen (29%) of the teachers offered definition that spanned three categories. Of the 33 teachers whose definitions spanned between two to three categories, 25 of them have had some form of training to teach integrated science while the remaining 8, although enjoyed no training at all, were experienced graduates from the university or colleges of education. These experienced teachers have been teaching integrated science for at least five years. In contrast, the 22 teachers who offered one category definitions were relatively young science teachers with between 1-4 years teaching experience and were trained to teach a single science and not integrated science. It is however doubtful if the definitions given by the teachers and categorised in figure 9.5, hold any particular consistent pattern but appear to be more random. In otherwords, it is unlikely that teachers' definitions conform to some definite pattern such that it could be said that a set of teachers X whose definitions conform to category (ies) a, b, c also did not subscribe to the definitions in category (ies) x, y, z and vice versa. That is, is there any correlation in teachers' responses?

A further attempt was made to establish if there is any correlation between the categories of definition proffered by the teachers. This is to say, whether teachers whose definitions for integrated science reflect or did not reflect category one of figure. 9.5 correlates with options in other categories. A measure of correlation was calculate^d by using the frequencies of teachers 'subscribing' or 'not subscribing' to a category of definition in fig. 9.5. This produces a fourfold contingency table as set out below:

		CATEGORY ONE		
		Not subscribe	Subscribe	Total
CATEGORY TWO	Subscribe	a	b	(a+b)
	Not subscribe	c	d	(c+d)
	Total	(a+c)	(b+d)	(a+b+c+d)

One measure of correlation derived from such a table, according to D. G. Lewis (1967), is the '*fourfold point correlation*', usually denoted by ϕ (phi). It is defined by:

$$\phi = \frac{bc - ad}{\sqrt{(a+b)(c+d)(a+c)(b+d)}}.$$

Obviously, the greater the numbers **b** and **c** (those who subscribed and did not subscribed to both categories) relative to **a** and **d** (those who subscribed to one category and did not, to the other), the greater ϕ becomes. If, however, the product **bc** becomes less than **ad**, ϕ will in fact be negative, showing an overall tendency for 'subscribing' to one category to be associated with 'not subscribing' to the other .

Using the ϕ correlation, the categories of definition in figure 9.5 were correlated with each other and the following results were obtained:

Table 9.2: Correlation (phi) for categories of definitions in figure 9.5

Categories correlated	ϕ (phi) Values
one & two	0.05
one & three	0.15
one & four	- 0.56
One & five	- 0.44
two & three	0.24
two & four	- 0.06
two & five	- 0.14
three & four	0.01
three & five	- 0.08
four & five	0

The ϕ correlation values for the categories of definition seems to have confirmed that there is no coherent pattern in the teachers' understanding of integrated science as is evident in the random definitions given by them. The ϕ values show very low

association. In fact, with the exception of the ϕ values for categories one & four and one & five which show some weak negative association (ϕ values of -0.56 & -0.44 respectively), most of the values tend towards no association at all.

9.3 HOW DO THE TRAINED INTEGRATED SCIENCE TEACHERS ASSESS THE TRAINING THEY RECEIVED?

Integrated science teachers who have undergone any formal training at all were asked to give an opinion on the training they received (see questions 16-20, Appendix C.iii), also to suggest ways they think the training might be improved. The teachers were also asked to say what influenced their choice for a part-time or full-time training.

The 12 trained teachers in the sample of 52 responded to this section. Of these, 7 had their training by part-time studies, the remainder by full-time training. The teachers trained part-time, gave these reasons for this choice of training:

- difficulty in securing study leave with or without pay from employers (both government and private);
- uncertainty over future job guarantee in the event of quitting a job for a Full-time study;
- institutions of choice run only part-time training for integrated science teaching.

It became apparent from these reasons given by the teachers that they would have preferred a full-time training but for the compelling conditions which made the opportunity for a full-time study difficult and daring. The result was that the cautious teachers had to settle for the part-time programme.

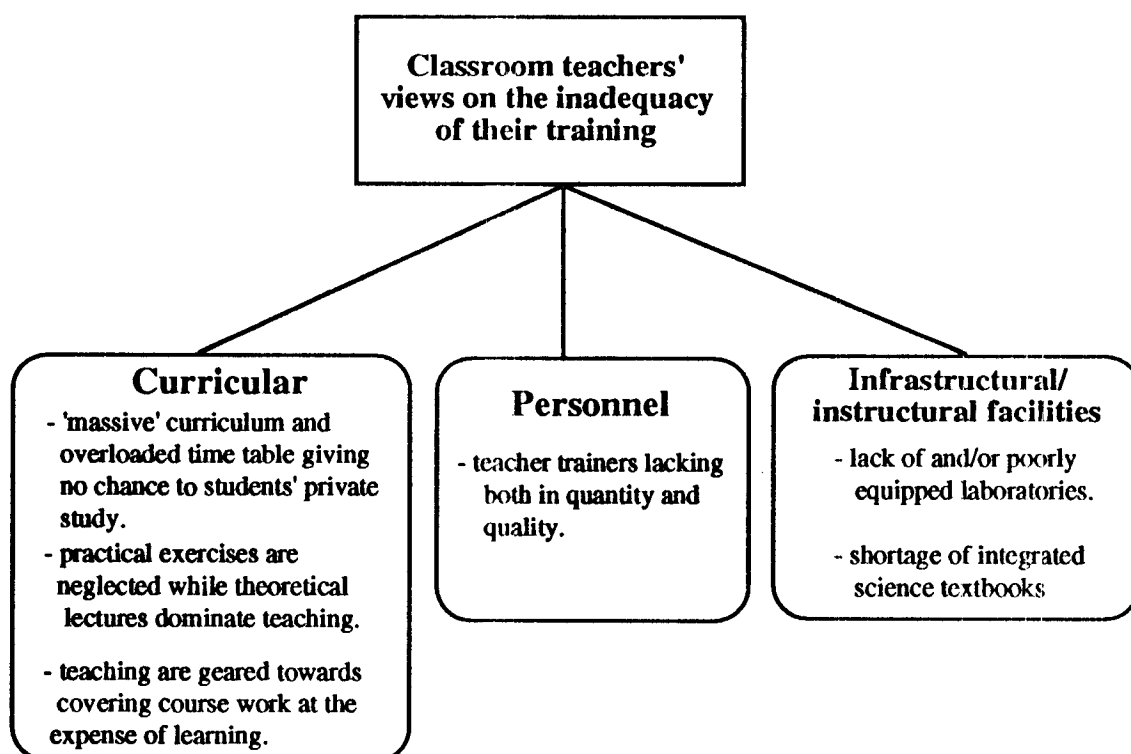
Teachers who undertook their training through full-time studies, however, believed they made the choice based on the conviction that they would learn better through the Full-time programme. That the full-time programme offers the advantage of enough time for studies, more opportunity to interact with other full-time students, the staff, and school learning facilities/environment. These privileges, the full-timers believed have higher chances of being enjoyed on Full-time study than are possible through part-time study.

The teachers were further asked to give a general assessment of the training they receive during the course of their training for integrated science teaching. Three categories of responses (Good; Fair; Inadequate) were provided to accommodate their reactions.

Their responses showed that with the exception of one teacher who assessed his training experience as 'good', all the other eleven teachers rated their training as 'fair'. No teacher rated the training received as 'inadequate'. In any case, the majority opinion about their training to teach integrated science was that it was averagely good (i.e. fair).

Their responses were followed by itemisation of areas of training they were dissatisfied with; and suggestion of ways the training can further be improved. These areas of dissatisfaction raised by the teachers could be classified as curricular, personnel and infrastructural/instructional facilities (fig. 9.6 below).

Figure. 9.6: Classroom teachers' perceived training in-adequacies.



The integrated science teacher training curricula, the teachers believed were over-ambitious and too massive for both the trainers and trainees to cope with. The results were that the teaching time table tend to be over-loaded giving the student teacher less free time for private studies. Similarly, science laboratory practicals and activities which could promote 'hands-on-science' were played down and in some cases totally neglected. The teacher trainers promoted more of the lecture method as it served the purpose of rushing through the course work to cover the 'massive' syllabus. This contradicts the objective of the inquiry teaching which is claimed by the integrated science curriculum developers to strongly underpin the teaching of integrated science.

The classroom teachers also listed the lack of sufficient teacher trainers (both qualitatively and quantitatively) in training institutions as a major crisis in the effective training of teachers of integrated science . This situation indeed confirms the status of teacher trainers earlier given by the course coordinators and analysed in table 8.3, page 179. The qualification of the participating teacher trainers in most institutions (table 8.3) reveals that most are not professional science educators nor have they had any training to teach integrated science at some point in their career.

Turning to problems associated with infrastructural/instructional facilities, the teachers itemised the lack of a well constructed and /or equipped laboratories. This is a condition observed to encourage much of the less desirable 'teaching about science' at the expense of 'doing science'. Secondly, the teachers complained of severe lack of integrated science text books relevant to the various aspects of the subject of integrated science that could assist both trainees in institutions as well as classroom teachers in schools and colleges. Although some of these relevant textbooks might be available in the market, government does not have plans to buy and supply the schools. The teachers and schools therefore have to make personal efforts to buy such books for themselves.

In suggesting ways that the training of teacher for integrated science could be improved for positive results, these teachers believed that all the above problems must, as a matter of priority, be addressed. Their suggestions, among others, includes:-

- Review and prune the 'massive' training curriculum to a relevant and manageable size.

- Initial teacher training for integrated science should be made a Full-time training with employers encouraged to grant favourable conditions to their employees who wish to take up the training.
- Construct and equip integrated science laboratories in training institutions and schools to reflect the unique and peculiar nature and demand of the course.
- Train and /or employ qualified/experienced teacher trainers who would be able to cope with the demand of the course as well as giving it the attention it deserves. The point being made here was that the teachers felt that some of the trainers got involved in the training merely for the sake of the monetary gain, a common phenomenon with part-time programme.
- Effort should be made to produce relevant textbooks especially on teacher education and the teaching of integrated science.

9.4 CLASSROOM TEACHERS' PERCEPTION OF THE CONCEPTUAL MEANING OF INTEGRATED SCIENCE AND WAYS IT MIGHT BE TAUGHT IN SCHOOLS.

The classroom teachers' perception of the conceptual meaning of 'integrated science' and ways it might be taught in schools were sought through the questionnaire. For this purpose, statements (extracts from literature reviews) which reflect points of view about the meaning of integrated science and ways it might be taught in schools were presented to the teachers for their responses. They were instructed to respond to these integrated science descriptors and pedagogies by agreeing, disagreeing or remaining neutral (undecided) on the relevance of the statements in describing the meaning of integrated science and ways to teach it. Agreeing with a statement means it expresses exactly or closely the respondent's perception of the meaning of integration in science and ways it can be taught, while disagreeing means, the statement has been perceived as unimportant and can be ignored or totally irrelevant as an integrated science descriptor or pedagogy. The response 'undecided' means the status of the statement cannot be decided.

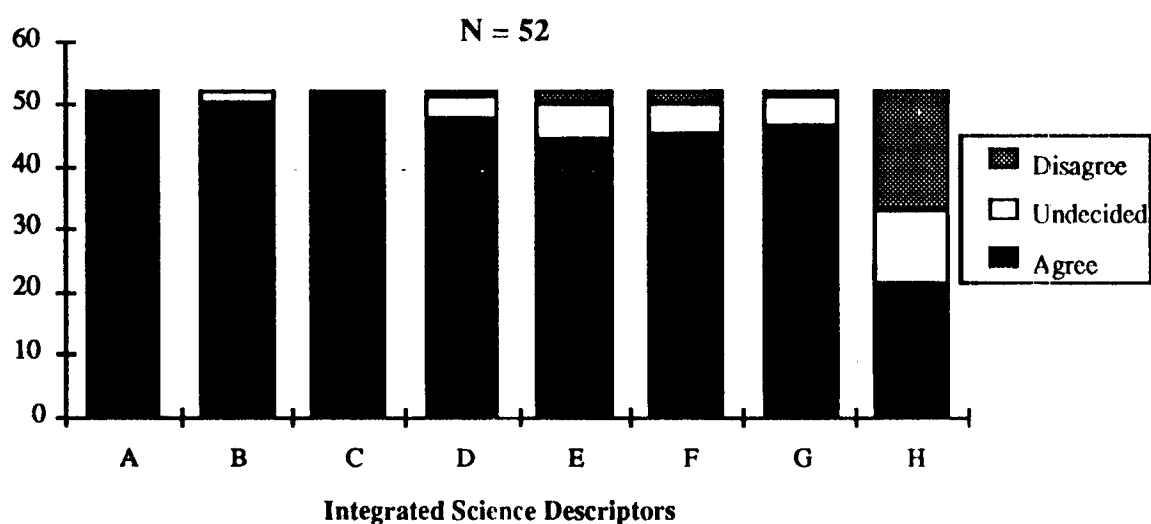
There were sixteen (16) items all together (8 descriptors and 8 pedagogies) to which the 52 teachers responded.

The responses of the classroom teachers are shown in the tables and figures below.

Table 9.3: Classroom Teachers' Perception of Integrated Science

Integrated science Descriptor	Classroom Teachers' Responses (F&%)		
	Agree	Undecided	Disagree
A. The acquisition of basic knowledge in the basic natural sciences and the earth sciences	52 (100)	0	0
B. The development of scientific attitudes.	50 (96)	2 (4)	0
C. Exploring the fundamental unity in all scientific knowledge.	51 (98)	1 (2)	0
D. Understanding the conceptual unity of the sciences.	47 (90)	4 (8)	1 (2)
E. Develop competence in the unified scientific process skills.	44 (85)	6 (11)	2 (4)
F. Exploring the relationship of science and technology.	45 (86)	5 (10)	2 (4)
G. Science courses should have strong links with environmental education.	46 (88)	5 (10)	1 (2)
H. The awareness of the limitations of science as a basis for dealing with moral and political problems	21 (40)	12 (23)	19 (37)

Figure 9.7: Teachers' Perception of Integrated science



The responses to the integrated science descriptors by the fifty two classroom teachers show a very high level of agreement (85-100%) among the teachers across seven of the eight descriptors. This gives an average of 92% agreement to items A-F as important and necessary in describing the meaning of integrated science. On the level of individual descriptors, the teachers show a 100% perception of item A: *"the acquisition of*

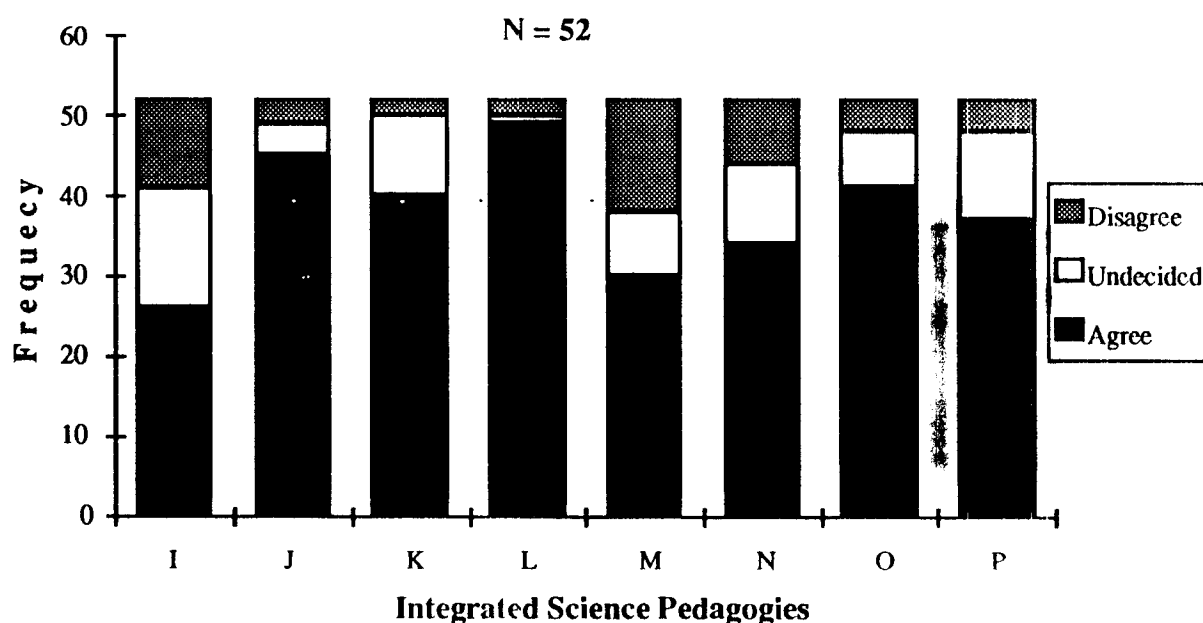
basic knowledge in the basic natural sciences and earth sciences" as the subject matter of integrated science. Similarly, the perception of integrated science as also concerned with "exploring the fundamental unity in all scientific knowledge", "the development of scientific attitude" and "the understanding of the conceptual unity of the sciences" show over 90% agreement among the teachers. Other integrated science descriptors as " the development of competence in the unified scientific process skills", "exploring the relationship of science and technology", and "relating science to environmental education" had over 80% agreement among the teachers. However only 40% (21 teachers) perceived integrated science as also concerned with creating "the awareness of the limitations of science as a basis for dealing with moral and political problems", 23% (12 teachers) were undecided, while 37% (19 teachers) totally rejected the item as fitting the subject of integrated science. The different position taken to by the teachers on this item is not totally surprising since over the decades, world wide, what science is and what it does have only been understood by the scientist. The public has an obscure understanding of the work of the scientist and science. Many integrated science programmes therefore have, besides other objectives, the promotion of scientific literacy and the public understanding of science. This objective of popularising science as part of the role of science education is probably yet to become a popular idea among the teachers of science. This could be a probable explanation for teachers' inability to see much of any relevance of science to social and political life.

All the teachers perceived integrated science as concerned with 'the acquisition of basic knowledge in the basic natural sciences and earth sciences' which matches closely the definition most of them (57%) presented when asked to defined integrated science in their own understanding. This number saw integrated science as a subject which combines learning materials from the basic natural sciences of biology, chemistry and physics (Fig. 9.5). There appears to be a positive relationship between the definition offered by the teachers in figure 9.5 and the choice made by them in table 9.3 above.

Table 9.4: Teachers' perception of integrated science pedagogies (i.e. ways it might be taught in schools)

Integrated science Pedagogies	Classroom Teachers' Responses (F&%)		
	Agree	Undecided	Disagree
I. Class discussion of social issues related to science should be considered an important type of school science lesson.	26 (50)	15(29)	11 (21)
J. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	45 (86)	4 (8)	3 (6)
K. Science schemes should be developed on a suitable psychological theory of learning.	40 (77)	10 (19)	2 (4)
L. A guided discovery approach to establishing concepts and generalisation should be used.	49 (94)	1 (2)	2 (4)
M. Collaboration wit teachers in departments other than sciences in necessary in order to integrate science in the curriculum	30 (58)	8 (15)	14 (27)
N. Team teaching is an effective way of teaching integrated science.	34 (65)	10 (19)	8 (15)
O. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of an particular contents.	41 (79)	7 (113)	4 (8)
P. Students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics.	37 (71)	11 (21)	4 (8)

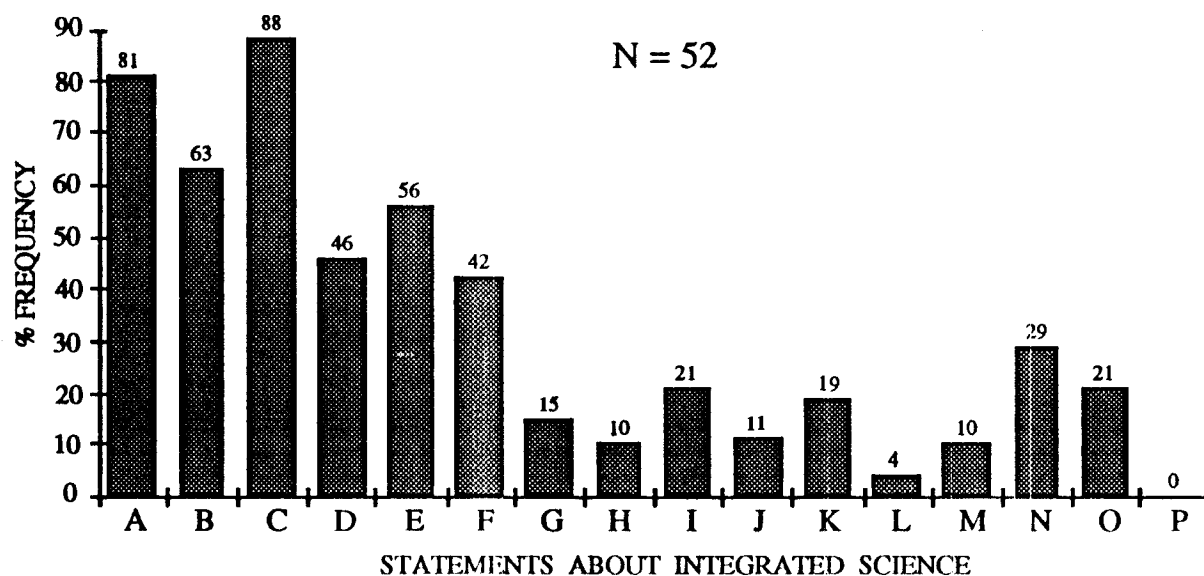
Figure 9.8: Teachers' Perception of integrated science Pedagogies



The responses to the integrated science pedagogies by the teachers show a less strong agreement to the items as compared to their responses to the items describing the meaning of integrated science (Table 9.4 & fig. 9.8). Only two items of the eight pedagogies had over 80% agreement among the teachers. As shown in table 9.4 and figure 9.8 above the pedagogies B & D ('the selection of aims of science courses and its teaching should take into account the everyday life of the students' and 'a guided discovery approach to establishing concepts and generalisation should be used in integrated science teaching'), had 86% and 94% agreement respectively. The other six items had between 50% and 79% with the item A ('class discussion of social issues related to science should be considered an important type of school science lesson') and item E ('collaboration with teachers in departments other than science is necessary in order to integrate science in the curriculum') registering the lowest acceptance (50% and 58% respectively) as relevant pedagogies for integrated science.

The teachers were asked to select from the list of statements (A-P) made about integrated science only five that, in their opinion, best describe the meaning of integrated science. Figure 9.7 below gives a picture of the range of choice made by the teachers.

Figure 9.9: Practising Teachers choice of five statements that best describe the meaning of integrated science in schools.



Although figure 9.9 above shows that the teachers choice of five statements spread widely across all the statements except item P, only items A B C D & E were highly regarded by the teachers as most essential in describing the meaning of integrated science. Thus a majority of the teachers believe that the main subject matter for integrated science in schools includes:

- the acquisition of basic knowledge in the basic natural sciences and the earth sciences;
- the development of scientific attitudes;
- exploring the fundamental unity in all scientific knowledge;
- understanding the conceptual unity of the sciences; and
- develop competence in the unified scientific process skills.

This opinion expressed by the teachers is strongly representative of the core ideas of most of the school integrated science programmes. Integrated science documents in the form of texts and curriculum materials examined by the researcher, particularly the Nigerian version, appear to be conveying these 'meanings'. What these statements stand for and how they are delivered in schools give rise to the different versions of integrated science programmes.

Despite the broad and embracing choice of the teacher as to what they thought were essential in describing the meaning of integrated science, they failed to represent their ideas in this way when asked to defined 'integrated science' in their own words. Rather, integrated science was defined in content terms, which teaches selectively combined subject matter from biology, chemistry and physics (represented here by their choice of the statement, "the acquisition of basic knowledge in the basic natural sciences...").

CHAPTER 10

ANALYSIS OF DATA FROM STUDENT TEACHERS.

This chapter analyses the data obtained from the integrated science student teachers and focuses on their understanding of integrated science and views about their training to teach integrated science. The questionnaires (Appendix Civ) were administered to all the 1992/93 final year integrated science student teachers in eight institutions; a hundred and forty four(94%) students responded to the questionnaire (see table 7.3).

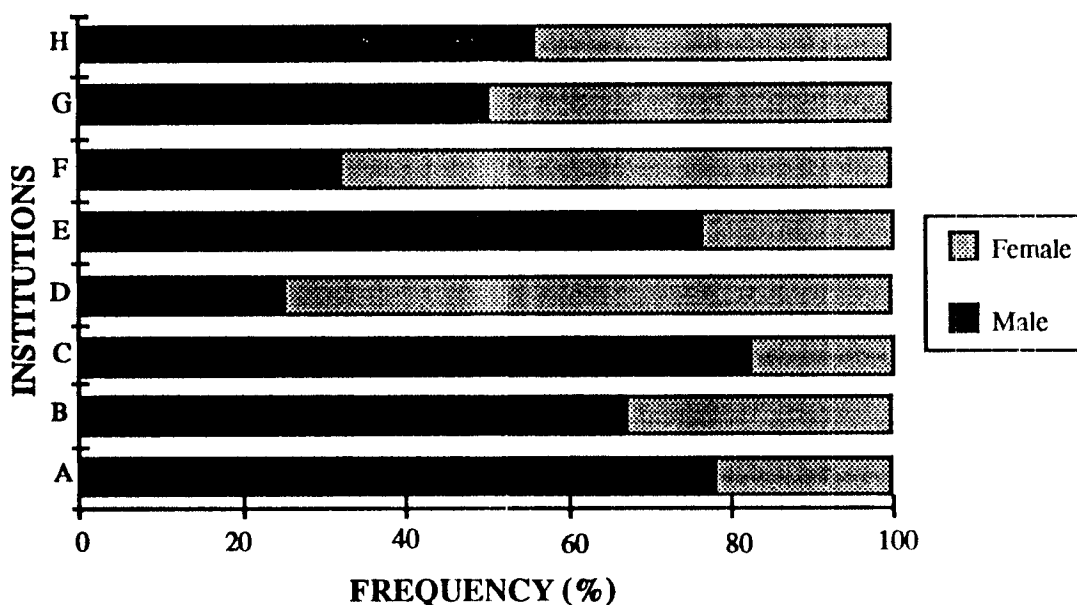
The questionnaire asked final year student teachers about their:

1. Science background which qualified them for admission to the college;
2. Their understanding of integrated science; and
3. Assessment of the training programme.

10.1 BACKGROUND OF INTEGRATED SCIENCE STUDENT TEACHERS.

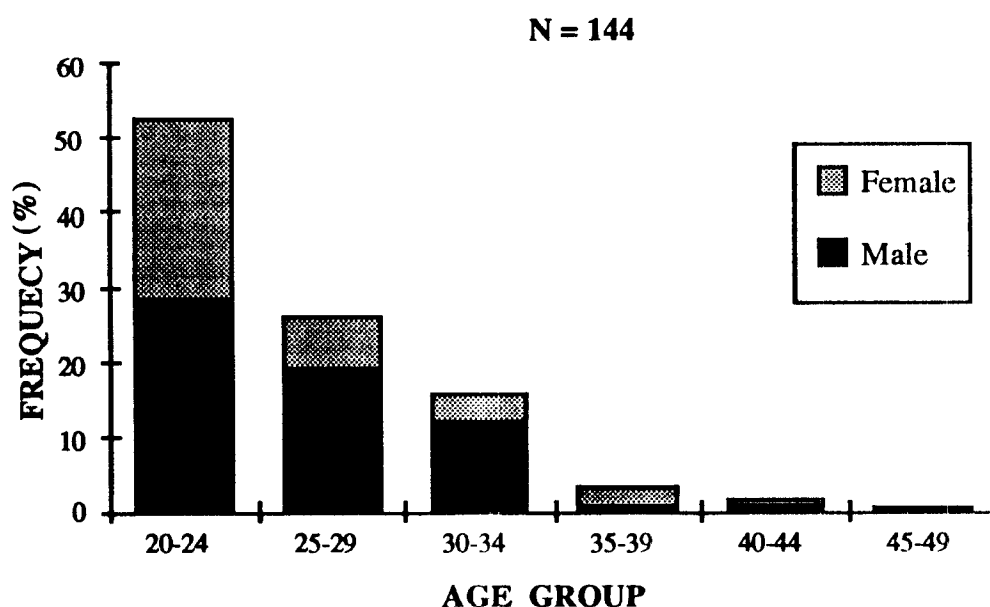
Information was collected on students' sex, age, qualification and science subjects background. The information obtained is represented in figures 10.1 to 10.4.

Figure. 10.1: Sex Distribution among Student Teachers.



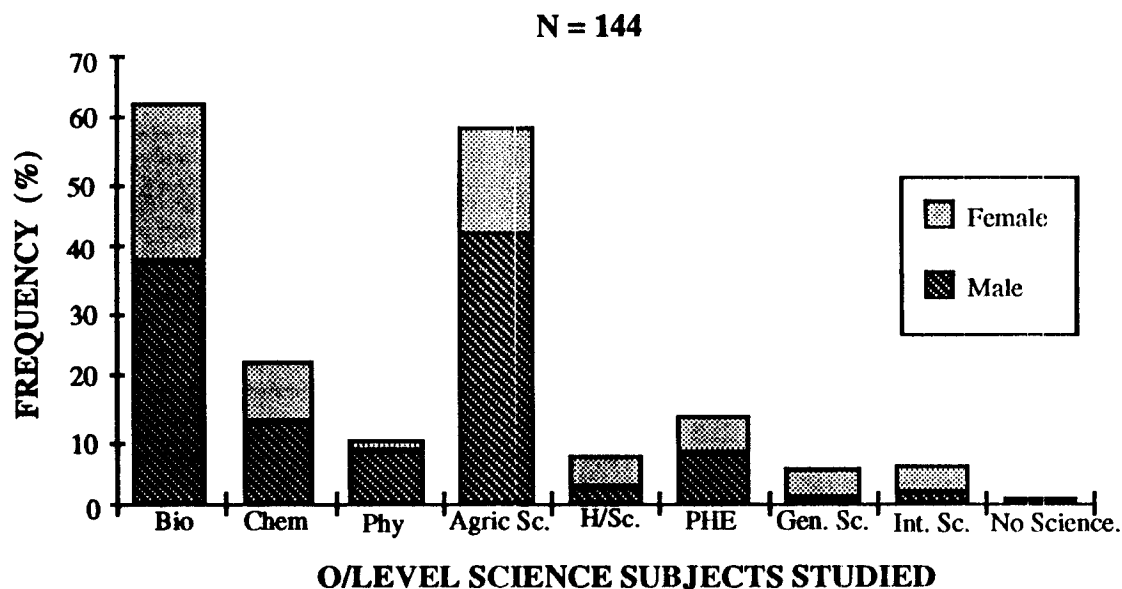
In figure 10.1, it appears the institutions do not consider gender as any important factor in their admission policy for the integrated science course. As such there is no striking pattern in the ratio of men and women admitted for training for integrated science teaching. The universities G & H have about equal number of males and females in training. In the case of the colleges of education, with the exception of two colleges (D & F) which have about 70% females to about 30% males each, all the other four colleges (A, B, C & E) have higher number (between 65 - 80%) of male students than females in their training programme. One would think that, since there was not gender admission policy, the gender ratios displayed here is merely an issue of chance rather than of any attributing reason. On the whole, it does appear that admission was given to any 'qualified' candidate irrespective of sex.

Figure. 10.2: Age Distribution among Student Teachers.



The age distribution among the student teachers in figure 10.2 shows that 103 of the 144 students (about 78% of the population) are below the age of thirty and 31 (22%) lie between the ages of 30 - 50 years. As the ages rises, men tend to dominate. Only 8 (6%) students fall within the ages 35 - 50. About 62% of the females (36 of 58) are between the 20 - 24 age group as against 45% males (40 of 86). Those who have Grade two teachers certificate foundation appear generally older than their GCE counterparts.

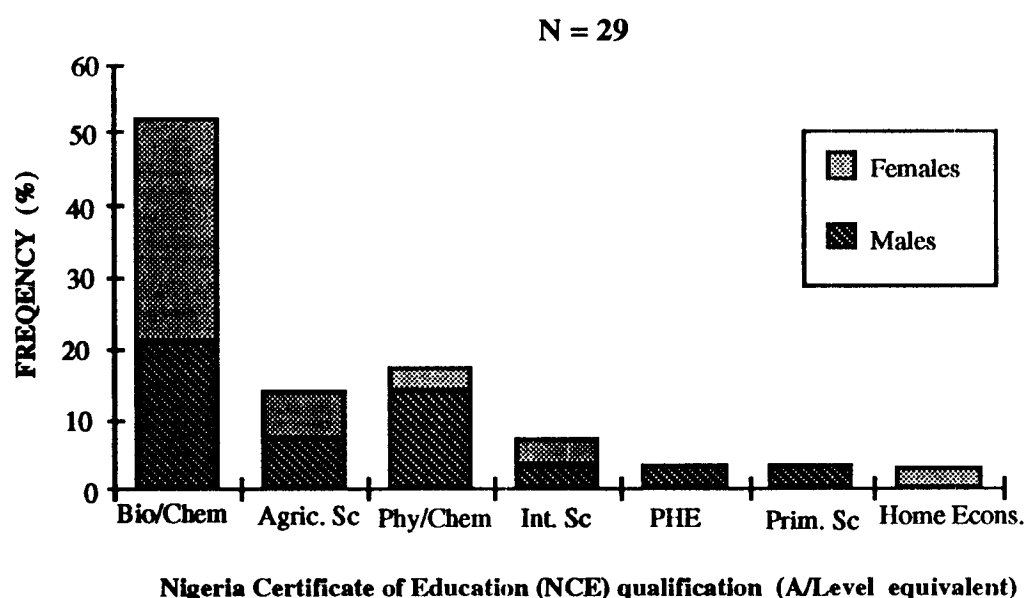
Figure 10.3: Science Background of Student Teachers.



Examining the science background of the student teachers (Fig. 10.3), the most common combination reveals that about 63% of the population had O/Level biology, 59% had Agricultural science, 30% had chemistry and only 9% had physics. About 34% of the student teachers (most of whom are holders of Grade two teachers certificates) were admitted with qualifications only in health science, physical and health education, general science and integrated science. Students with integrated science background constituted only 4% of this population. Until recently, the Grade Two Teachers' Colleges did not teach the three basic sciences as part of the school curriculum; but science was taught as "general science". So it was not unusual to find that most of the grade two holders had deficient backgrounds in biology, chemistry and physics. However, from the gender point of view, there appears to be some differences in the science background between the males and females. There are about 46% males as against 28% females who hold qualifications in biology, chemistry and physics. There are only 11 male students and 2 female students with physics background. Most of the students who hold the Grade two certificate background show very weak background in the physical sciences, For the more general background in science such as in health science, general science, integrated science and physical and health education, there are 14% females to 12% males who were

admitted with such background. A majority of these students hold the Grade two certificate background. In summary, then a typical student teacher of integrated science in the institutions studied had an O/level biology/agricultural science background. This science background for a typical student of integrated science did not vary with the sex of the students. There is however marked deficiency in students with backgrounds in physical sciences, especially of women with physics.

Figure.10.4: A/Level Science Background for Student Teachers admitted for Integrated Science Degree Course in the Universities (G & H).



The advanced level science background for the student teachers (Fig. 10.4) admitted for the integrated science degree course in the universities (G & H) revealed that, with the exception of one student who held a diploma, the remaining 99% students were holders of the Nigeria Certificate of Education (NCE), an A/Level equivalent. About 52% (15) qualified in a combination of biology/chemistry, 17% (5) with agricultural science, 14% (4) in physics/chemistry. Only 2 students had qualifications in integrated science and one each in primary science, physical and health education and home economics. In other words the background of integrated science university undergraduate teachers are in the separate sciences, typically in the biology/chemistry combination.

10.2: DEFINITION OF INTEGRATED SCIENCE HELD BY THE STUDENT TEACHERS.

The final year students of integrated science in the colleges of education as well as those of the universities were asked to describe their understanding of integrated science. The research drew data exclusively from the final year students; it was felt that they would be in a better position to respond to such question having been influenced for at least two years by their training to teach the subject.

The respondents were requested to define integrated science the way they understand it. Of the 144 respondents, 18 (12.5%) did not present any definition, most of these were holders of the grade two teachers' certificate. No reason was given by the candidates for their action. This might as well be interpreted as a show of lack of confidence in their understanding of the subject or an inability to define integrated science in their own way. Definitions given by the remaining 127 others however revealed a range of understanding about integrated science. The definitions, like those of the practising teachers (see section 9.2), range from very narrow definition of integrated science as a subject which teaches about the scientific process skill, to as wide a definition as the study of the universe.

The six categories of integrated science definitions which resulted from the analysis of those given by the practising teachers (figure 9.5 page 197) fit closely the range of definitions given by the integrated science student teachers. Some 60% (87) of the student teachers saw integrated science solely and exclusively as a subject which combines contents from other science disciplines, principally of biology, chemistry and physics (category 1). A few students (11 of 87) saw integrated science as dealing with many more issues than just the combination of contents from the three basic sciences; hence their definition of integrated science were more broad and spanning two or more categories. About 18% (26) defined integrated science as an approach to the teaching of science as unity (category 2). Only about 7%, 6%, 1% and 3% student teachers had definitions falling into categories 3, 4, 5 and 6 respectively. Most of the students teachers (131 or 91%) presented narrow definition of integrated science fitting only one category,

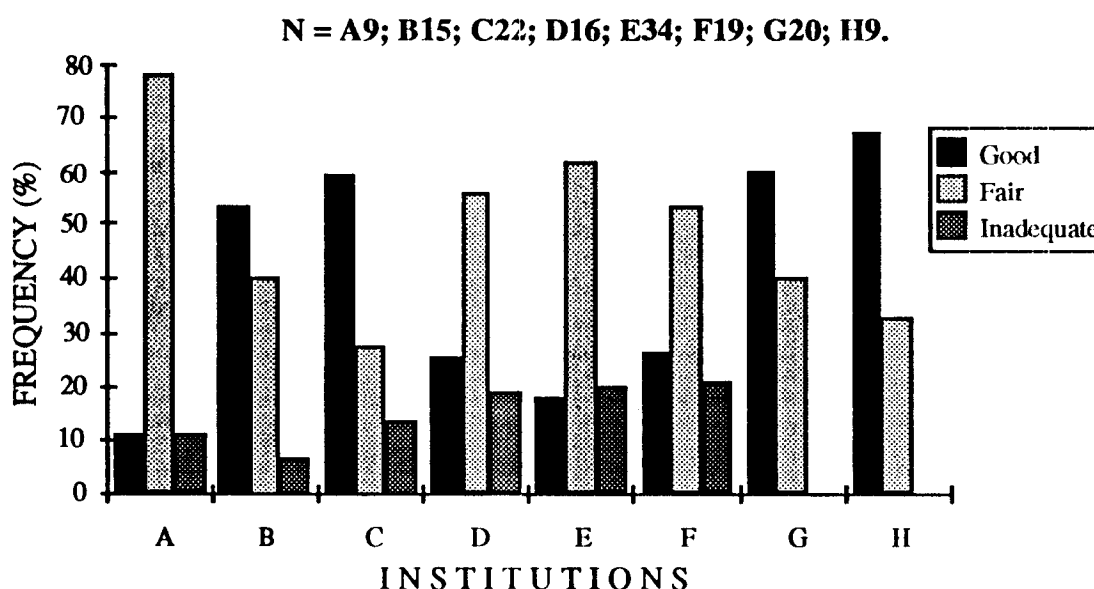
only 9% presented definitions broad enough and were placed into more than one category.

10.3: ASSESSMENT OF TRAINING PROGRAMME BY THE INTEGRATED SCIENCE STUDENT TEACHERS.

The final year student teachers were asked to assess the training they were receiving for the teaching of integrated science. They were provided with three categories of responses (Good, Fair or Inadequate) with which to express their general feelings about the training. In addition, the questionnaires offered them opportunities to say what they thought was deficient in their training or they were dissatisfied with in the training programme; and of ways by which the programme could be improved.

Based upon the three category responses, the reaction of the students for each institution has been presented in figure 10.5 below:

Figure.10.5: Student Teachers' Assessment of their Integrated Science Training Programmes in their Different Intitutions.



Of all the integrated science teacher training programmes going on in the six colleges of education (A-F) and the two universities (G & H), only colleges B & C and both universities had their training programmes rated as "good" by about 53%, 59%, 60%, and 67% of their students respectively. In summary, 4 of the 8 institutions were rated 'good'; 2 of these were the university departments and the remaining 2 were colleges

of education known to be pilot colleges for the Nigerian Integrated Science Teacher Education Project (NISTEP). Although 3 colleges of education sampled for this study were NISTEP pilot colleges whose teaching staff have been benefiting from training to teach integrated science at Kings College, London, only the 2 rated 'good' are known to still retain the trained staff while the other one had lost the services of its trained staff to other jobs. The remaining colleges of education (A, D, E & F) have less than 30% of their student teachers rating their experiences from their training programme as "good". Tables 10.1 and 10.2 below show the relationship between the student teachers' background qualification, gender and the assessment of their training experiences.

Table 10.1: Student Teachers' background and Rating of their Training Experiences

O/L Background	ASSESSMENT OF TRAINING PROGRAMME			
	Good	Fair	Inadequate	TOTAL
WASC/GCE	51 (55)	36 (39)	6 (6)	93 (100)
GRADE II	4 (8)	33 (65)	14 (27)	51 (100)
TOTAL	55 (38)	69 (48)	20 (14)	144

NB. figures in brackets are percentages.

Table 10.1 shows that of the 93 student teachers who were holders of the West African School Certificate and/ or the General Certificate of Education, 55%, 39% and 6% of them rated their training programme as 'good', 'fair' and 'inadequate' respectively. On the other hand, of the 51 student teachers who were holders of the Grade two teachers' certificate, only 8% rated their training experiences as 'good', 65% as 'fair' and 27% as 'inadequate'. This means that student teachers whose background qualification is the WASC/GCE certificate are more likely to rate their training experiences as 'good' than the holders of the Grade II certificate. This suggests that student teachers with the Grade II certificate find the integrated science course more difficult than their WASC/GCE counterpart.

Table 10.2: Assessment of integrated science training programme by gender

GENDER	ASSESSMENT OF TRAINING PROGRAMME			
	Good	Fair	Inadequate	TOTAL
MALE	37 (43)	38 (44)	11 (13)	86 (100)
FEMALE	18 (31)	31 (53)	9 (15)	58 (100)
TOTAL	55 (38)	69 (48)	20 (14)	144

NB. figures in brackets are percentages.

In table 10.2, the integrated science training programme gender rating pattern shows that of the number of 86 male students, 43% rated the programme as 'good', 44% said it was 'fair' and 13% said the effort was 'inadequate'. On the other hand, 31% of the female students felt the training was 'good', 53% rated it as 'fair' and the remaining 15% described their experiences as 'inadequate'. There is evidence that male student teachers are more likely to enjoy the integrated science course than their female counterparts. Generally, more student teachers irrespective of their qualification and gender, tend to see the integrated science training as 'fair'. In an interview with some of the students to understand what they meant when they assessed their training as 'fair', it was understood that such students were finding the course quite difficult and uninteresting. They were therefore using 'fair' modestly, but almost synonymous^{ly} with expressing a complete dissatisfaction with the course.

The student teachers also listed areas in their integrated science training which they perceived as deficiencies and dissatisfactions. They also suggested ways their training programme for integrated science teaching could be improved.

The student teachers' list of what they considered as problems in their training fall into about the same categories as those of the integrated science practising teachers established from similar responses in the last chapter (page 201). The problems are related to either curricular, personnel and facilities; there is a category of problems related to the admission policy. Curriculum related problems raised by the students include their complaint about the curriculum being generally too large. The results were that the teaching timetable became overloaded, practical and field exercises were often ignored.

Turning to teaching personnel, the students lamented that both the science and science education teaching staff were lacking both in quantity and quality. Even the few that were available did not take the job seriously as most of them, borrowed from other single science departments, did not see themselves as qualified for the educational work and that it wasn't their primary responsibility. They were therefore showing a general lack of interest, enthusiasm and little commitment to the success of the integrated science training. A comment by one of the students, typical of many other students about the problem of teaching staff in their institutions, reads:

we do not have qualified teachers and those helping from other departments tend to show no interest in its teaching

The lack of infrastructural and instructional facilities such as laboratory building and equipment were listed by over 90% of the student teachers. Their observations range from lack of purpose built laboratory, which in some cases normal lecture classrooms were being used as laboratories, to poorly equipped laboratories. Of the eight institutions visited in the course of this research, only two of them had laboratories referred to as 'integrated science laboratories' while in a majority of cases, laboratories were shared with separate sciences departments. This laboratory sharing limits the students laboratory experiences especially when the time tabling for the laboratory use tend to be very tight and the students may or may not have the opportunity to make occasional individual/private appearances in the laboratories for private exercises.

The problem of lack of relevant text books for integrated science that could be of assistance to the student teachers were raised by a large number of the students. Of particular relevance in this respect are texts on the pedagogies of integrated science covering, among others, such things as the conceptual meaning and the philosophical basis for integrated science in the Nigerian classroom. The researcher observed that much more effort has been put on the ground to produce textbooks covering the content material to be taught relevant to the curriculum for the Junior Secondary Schools for which the teachers were trained to implement. However, very little effort had been made to produce texts that could be of help to the trainee teachers. Even the very few that were

there in the market were very expensive (including the locally written ones). Yet in the face of this difficulty in acquiring these rare but essential texts by the student teachers, none of the institutions visited had any good integrated science library resources to assist the needy students.

Some student related problems raised by the students themselves border around the admission policy of the training institutions. A number of the students believe that, fundamental to the deficiency or dissatisfaction in the integrated science training programme was the poor selection of the candidates for the course. They observed that contrary to the expectation of a strong background in the natural sciences for candidates to benefit maximally from the integrated science course, some of the admitted candidates were either completely lacking in the science background or grossly deficient in it. A typical comment by one of the students reads: *"...students who had not applied for the course have been forced into it"*. This meant that some of the students being trained for integrated science teaching did not initially applied for the course but were offered it as second choice. The case here is that the student might have applied for other science courses but found to be basically unqualified for the choice, the integrated science course was therefore offered by the admission authority as an alternative. This alternative might not necessarily^{ily} be a choice for the applicant. Hence, for either lack of interest or deficient background in the relevant sciences, such students have found the course uninteresting or difficult to cope with. In fact evidence of the poor science foundation by most students is clear from figure 10.3, page 211 where quite a few (3%) of them claimed to have qualified O/L background for all three sciences (physics, chemistry and biology), about 19% with only biology and chemistry. The rest of the students hold passes in one science or the other, largely biology and/or agricultural science. Indeed a number of some students were admitted with the more general background in science. In one of the institutions, a student was found to have been admitted to read integrated science without a single science subject but with a background in economics. Another student, holding the Nigerian Certificate in Education in Home Economics was also given admission to read for a degree in integrated science. From interview with such students, it was understood that they were finding the course extremely difficult but hung on if only to

manage to the end and obtain their motivating ambition - a university degree or a higher academic qualification.

With such admission practices, it would be appropriate to conclude that the institutions have very liberal and low admission standard for the integrated science course. This is evident in the fact that even students with very weak or no science background have been admitted, which, very likely, could have been a contributing factor to the difficulty being experienced by such students in the integrated science course.

The student teachers, having made these observations on the deficiencies or problems with their training programme, suggested ways they believe the integrated science teacher training programme could be improved. Their suggestion includes:

- 1 - employ more integrated science teacher trainers and provide training for them as well as providing incentives to retain the trainers on the job;
- 2 - provision of well equipped 'integrated science' laboratory where practical exercises could be held regularly as needed;
- 3 - provide relevant integrated science text materials and instructional facilities that can be of help to both teacher trainers and the students;
- 4 - give admission only to candidates who hold interest in as well as possessing the admission requirements for the integrated science course;
- 5 - review the 'massive' integrated science teacher training curriculum as well as the teaching time table;
- 6 - Integrated science course should be made 'double major'³ as against the traditional 'single major'⁴ courses in the colleges of education.

³ & ⁴ - Single and Double major courses: Traditionally, a student studying for the Nigerian Certificate of Education, (usually at a colleges of education) may offer a combination of two subject disciplines referred to as "single majors" or one subject discipline, in this case, known as a "double major". The double major courses (e.g. Agric. science, Home economics, Integrated science etc.) are considered to be reasonably and sufficiently 'large enough' for a profession.

10.4 STUDENT TEACHERS UNDERSTANDING OF THE CONCEPTUAL MEANING OF 'INTEGRATED SCIENCE' AND WAYS IT COULD BE TAUGHT IN SCHOOLS.

In an attempt to find out how the integrated science student teachers understand the meaning of 'integrated science', they were presented with a set of eight statements describing the concept of 'integrated science' and another set of eight pedagogical statements describing how integrated science could be taught in schools. They responded to the statements in a similar pattern as was done by the practising teachers of integrated science. That is, to 'agree' or 'disagree' with a statement if it matched or did not match the respondent's understanding of the meaning of integrated science or the way it might be taught in schools. They may remain 'undecided' about a statement (see section 9.4, page 203 for details about the task).

The responses of the 144 student teachers are shown in the tables below:

Table 10.3(a): Student Teachers' Perception of Integrated Science.

Integrated Science Descriptor	Student Teachers' Responses (F& %)		
	Agree	Undecided	Disagree
A. The acquisition of basic knowledge in the basic natural sciences and the earth sciences	136 (95)	6 (4)	2 (1)
B. The development of scientific attitudes.	135 (94)	6 (4)	3 (2)
C. Exploring the fundamental unity in all scientific knowledge.	130 (90)	8 (6)	6 (4)
D. Understanding the conceptual unity of the sciences.	123 (85)	12 (8)	9 (6)
E. Develop competence in the unified scientific process skills.	128 (89)	7 (5)	9 (6)
F. Exploring the relationship of science and technology.	119 ((83)	13 (9)	12 (8)
G. Science courses should have strong links with environmental education.	93 (65)	23 (16)	28 (19)
H. The awareness of the limitations of science as a basis for dealing with moral and political problems	132 (92)	7 (5)	5 (3)

The students response in table 10.3(a) shows a general high agreement to items A-H as describing the subject matter of integrated science; there are low cases of disagreement as well as undecided cases. There are, however, slight variations on the students' consensus on the individual items. The students show high agreements (between 83-95%) for most of the integrated science descriptors. Only item G registered as low as

65% acceptance among the students, that is to say that a relatively high number of students did not see integrated science as concerned with environmental education. Item H (*'the awareness of the limitations of science as a basis for dealing with moral and political problem'*) has been highly perceived by 98% of the student teachers as a relevant subject matter for integrated science as compared to the very low perception (40%) by the classroom teachers (see table 9.2).

Table 10.3(b): Response pattern of students by Gender and basic qualification (GCE & Grade II)

Item	AGREE (%)				UNDECIDED (%)				DISAGREE (%)			
	M	F	GCE	GdII	M	F	GCE	GdII	M	F	GCE	GdII
A	95	93	97	90	4	5	2	8	1	2	1	2
B	95	88	97	88	4	7	2	8	1	5	1	4
C	93	84	93	84	4	9	4	12	3	7	2	3
D	91	78	92	72	6	12	7	12	3	11	3	16
E	93	83	92	82	4	7	4	6	3	11	3	12
F	84	81	86	76	9	9	7	12	7	11	6	12
G	73	52	76	43	13	21	15	18	14	28	9	39
H	98	83	98	80	1	9	1	11	1	9	1	11

N = 144: [M = 86, F = 58]; [GCE = 93, Grade II = 51].

When the response pattern of the students were further examined against some variables such as their gender and entry qualification for the integrated science course, it revealed some striking differences as shown in table 10.3(b). Generally, more male students showed higher agreement to the items with lower cases of disagreement and neutrality (undecided) than their female colleagues. Similarly, holders of the General Certificate of Education (GCE) showed higher agreement to the items as well as showing lower cases of disagreement and neutrality than those whose background qualification is the Grade II certificate. This shows that female students and holders of the Grade II teachers' certificate are less likely to see the items A- H as the subject matter of integrated science than do male students and holders of the General Certificate of Education (GCE).

Table 10.4(a): Student teachers' perception of integrated science pedagogies (i.e. ways it might be taught in schools)

Integrated science Pedagogies	Student Teachers' Responses (F& %)		
	Agree	Undecided	Disagree
I. Class discussion of social issues related to science should be considered an important type of school science lesson.	131 (91)	8 (6)	5 (3)
J. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	121 (84)	14 (11)	9 (6)
K. Science schemes should be developed on a suitable psychological theory of learning.	121 (84)	17 (12)	6 (4)
L. A guided discovery approach to establishing concepts and generalisation should be used.	86 (60)	33 (23)	25 (17)
M. Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum.	114 (72)	26 (18)	14 (11)
N. Team teaching is an effective way of teaching integrated science.	111 (77)	16 (11)	17 (12)
O. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of an particular contents.	118 (75)	23 (16)	13 (9)
P. Students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics.	57 (40)	45 (31)	42 (29)

Table 10.4(a) shows that, generally, the student teachers agreed with items I-P as relevant pedagogies (ways integrated science could be taught in schools); the strength of agreement isn't as high as shown for the integrated science descriptors. More students remained undecided for most items than they disagreed. All, except two, of the pedagogies had over 70% each of the students' consensus as meaningful strategies for teaching integrated science in the school.

Only item L (a guided discovery approach to establishing concepts and generalisation should be used) and item P (students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics)

had 60% and 40% students acceptance respectively as methods that could be useful for teaching integrated science in schools. Nevertheless, the two items were neither strongly objected to as useful pedagogies, rather, most of the students remained 'undecided' on their suitability.

Table 10.4(b): Response pattern of students by gender and basic qualification (GCE & Grade II) to the integrated science pedagogies.

Item	AGREE (%)				UNDECIDED (%)				DISAGREE (%)			
	M	F	GCE	GdII	M	F	GCE	GdII	M	F	GCE	GdII
I	92	91	94	92	6	3	4	4	2	5	2	4
J	85	86	87	88	9	7	7	8	6	7	6	4
K	88	81	85	86	7	17	11	12	5	2	4	2
L	66	53	61	70	15	31	22	18	19	16	17	12
M	72	62	72	72	15	26	16	14	13	12	12	14
N	79	76	77	78	9	12	8	16	12	12	15	6
O	77	74	72	82	15	16	18	11	8	11	11	8
P	44	40	37	53	33	22	31	24	23	38	32	23

N = 144: [M = 86, F = 58]; [GCE = 93, Grade II = 51].

Although the responses of the students by gender and qualification to the pedagogical items in table 10.4(b) above revealed no strong striking features with respect to the variables considered, there are notable differences. The female students show lower agreement to the items as well as show higher tendency to disagreeing with or remaining 'undecided' on the items than their male counterparts. This higher positive response by the male students was also revealed in their responses to the concept on integrated science described in table 10.3(a & b).

Considering the responses to the integrated science pedagogies by the GCE holders and holders of the Grade II teachers' certificate, the converse is the case. Holders of the Grade II certificate show higher agreement to the pedagogies and less tendency to disagreeing with or remaining undecided on the items than their GCE counterparts. This result is not surprising as the Grade II teachers' certificate holders have the advantage of having gone through professional training to teach in the primary schools before embarking on this further teacher training for the secondary. Their GCE colleagues are however encountering professional training for the first time, particularly for those receiving their training for the Nigerian Certificate of Education (NCE).

From the list of sixteen statements (A-P), the students were requested to select any five which they consider most essential in describing the meaning of integrated science in schools. The frequency chart (Figure 10.6) below gives details of the students' opinion.

Figure 10.6: Student Teachers' choice of Five statements that best describes the meaning of Integrated science in schools.

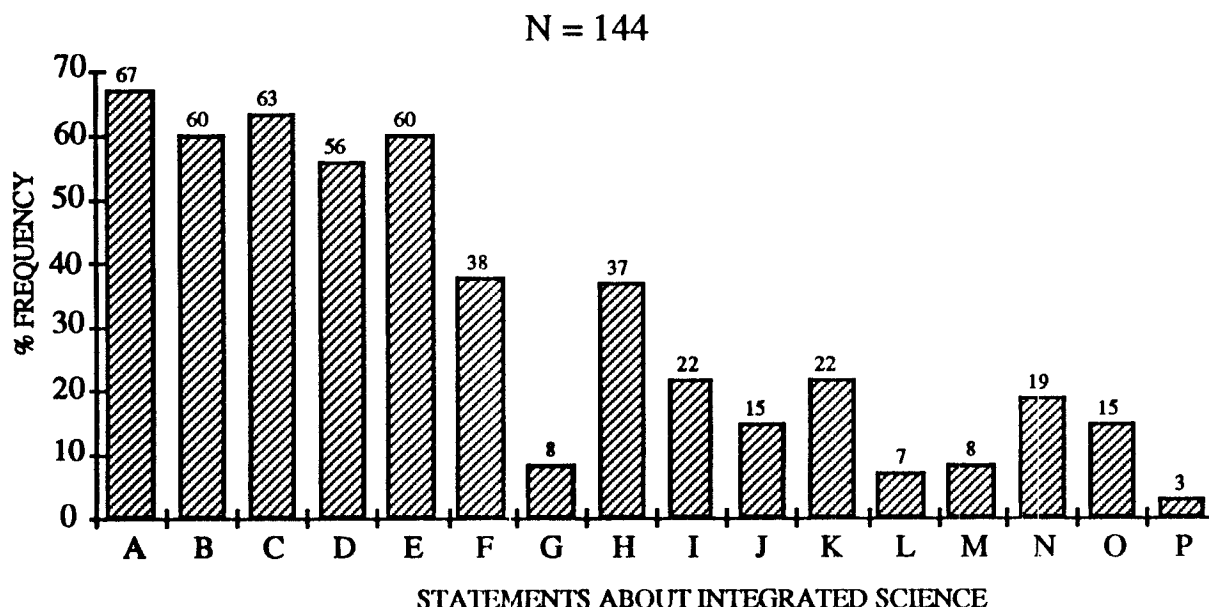


Figure 10.6 above shows that over 60% of the student teachers subscribed to the statements A - E as the best five which essentially describes the meaning of integrated science in schools. In other words the students strongly believe that the main subject matter of integrated science in schools are :

- the acquisition of basic knowledge in the basic natural sciences and the earth sciences;
- exploring the fundamental unity in all scientific knowledge;
- the development of scientific attitudes;
- develop competence in the unified scientific process skills; and
- understanding the conceptual unity of the sciences.

Indeed the students' choice of the statements that best describe the meaning of integrated science is identical to those selected by the secondary school classroom teachers (fig. 9.9 page 207). This choice by the students certainly represents more of the broad meanings of integration in science (Chapter 3) than their personal definitions offered in section 10.3 where most of the students subscribed to defining integrated science as a subject which teaches combined subject matter from biology, chemistry and physics.

Following the students' responses to the questionnaires, interviews were conducted with about five (5) students from each institution. The interviews, based more on the questionnaire questions, were intended to give support to their written responses. Of about 42 students interviewed in this way, 81% show consistency with the trend of questionnaire responses analysed above. Only 19% changed their opinions on three of the items:

- **G** (Science courses should have strong links with environmental education);
- **M** (Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum); and
- **P** (Students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics).

They had interpreted and responded to these three statements differently when responding to the questionnaires. However, when the statements were elaborated upon during the interview, the students changed their initial responses from 'undecided' in favour of 'agreement'. They now saw some relevance of the items as descriptors or pedagogies for integrated science in schools.

Although both the questionnaire and the interview responses by the students showed high agreement with the statements A - P, the impression given by the interviewees, in particular, suggested that their experiences of the trends in integrated science teaching was not giving them much of the kind of experiences they checked "agreed" on the questionnaire. This meant that the students responses to most of the statements were likely reflecting more of theoretical and hypothetical convictions than of real experiences.

CHAPTER 11

ANALYSIS OF DATA FROM THE TEACHER TRAINERS.

This section analyses the data obtained from college and university lecturers who were responsible for the training of teachers to teach integrated science in schools. A total of 60 teacher trainers from the 8 institutions covered by this study responded to the questionnaires. The questionnaire, which has a format similar to those used for the student teachers and the classroom practising teachers, sought to collect information from the teacher trainers about their:

- perception of the concept of integrated science in schools in Nigeria;
- views of what they consider to be the most relevant issues for the curriculum for training teachers of integrated science in Nigeria; and
- views about the teacher training for integrated science in their institutions.

11.1 BACKGROU^ND OF TEACHER TRAINERS.

The scientific qualifications, educational training and other experiences relevant for the job of training integrated science teachers were collected by questionnaire from 60 teacher trainers.

This showed that 45% were graduates of biology, 25% of chemistry, 20% of physics and 10% of mathematics. While there was a fair spread of the biology lecturers within the eight institutions covered in this research, the same is not true of chemistry, physics and mathematics lecturers, to the extent that some of the institutions show acute shortage of graduate lecturers in some of these disciplines, in particular, mathematics and physics. More than 90% of the teacher trainers at the colleges of education were found to be professional science educators with less than 10% not professional science educators (i.e. they hold qualifications in science disciplines but not trained to teach). The reverse is the case with the trainers in the universities. This finding was not surprising since the colleges of education were established purely with the objective of training teachers.

Consequently, their staff employment policy gives priority to graduates with educational expertise. Although the university departments of education train professional teachers as do the colleges, they do so entirely through collaboration with other departments (science or arts) of the university; their students receive teaching in their teaching subject courses at these other departments while the education courses are taught at the education faculty. It is therefore a common feature to find that, in the university departments other than of education, the trainers are lacking in educational qualification.

Table 11.1 displays the responses of the teacher trainers to the questions of whether they have had any training course for integrated science teaching; and whether they felt the job of training integrated science teachers was the most suitable and enjoyable work in view of their qualification.

Table 11.1: Teacher trainers experiences with integrated science and suitability to job of training secondary school teachers of integrated science.

Response	Int.Sc training experience	Suitability to Job*
YES	23 (38)	20 (33)
NO	37 (62)	40 (67)
Total	60 (100)	60 (100)

N = 60

NB: number in brackets are %

Table 11.1 shows that over 60% of the teacher trainers participating in the training of integrated science teachers have not benefited from any integrated science training. Similarly over 60% also indicated that, in view of their qualification, they felt that their involvement in the integrated science teacher training programme is not the most suitable job for them. Hence, for whatever reasons such teacher trainers were participating in the training programme, they strongly felt they were in the wrong place. Most of the trainers who felt this way were graduates who held no education qualification and neither benefited from any training course that could familiarise them with the objectives, philosophy and perhaps, the teaching strategies for integrated science. This result could

* The questionnaire requested the teacher trainers to assess their 'suitability' in terms of whether they personally feel they are competent to participate in the training of teachers for integrated science in view of their qualification, training and teaching experience .

be an indication that the integrated science teacher training classroom is largely populated with inexperienced and unenthusiastic staff.

11.2 DEFINITION OF INTEGRATED SCIENCE BY THE TEACHER TRAINERS.

The teacher trainers description of their understanding of integrated science revealed a less wide range of definitions than were presented by the classroom practising teachers and the student teachers. While the definitions given by the practising teachers and the student teachers were grouped into six categories as displayed in figure 9.5, those of the teacher trainers fitted into only three of the six categories. A majority of the trainers (57%) described their understanding of integrated science in the context of category one: "the teaching of a combination of content materials drawn from biology, chemistry and physics"; many of whom also believed that it is an elementary teaching of these sciences. About 18% of the trainers, all of whom were professional science teachers educators and have also benefited from integrated science training course of some sort, described integrated science as an approach to the teaching of science as unity (category two). Another 13% saw integrated science as concerned with the inculcation of scientific attitudes and the process skills (category three). Only about 12% of the teacher trainers were able to offer more broad definitions of integrated science that spanned two categories.

Ten of the sixty teacher trainers (about 17%) responded with "not much" or "it is the teaching of elementary science" or left blank spaces, to this question asking them to describe their understanding of integrated science. At least this is an indication that this group of teachers were participating in a programme they did not quite understand what it is all about. This revelation was hardly surprising as the background of these teachers shows that most of them were not professional science teacher educators and have neither benefited from any training for integrated science teaching. They also indicated clearly in their questionnaire responses that the job of participating in training teachers of integrated science was unsuitable for them.

The views of integrated science presented by the teacher trainers as either:

- a subject which teaches a combination of subject matter from biology, chemistry and physics;
- an approach to the teaching of science as unity; and
- the inculcation of scientific attitudes and the process skills,

reflect bits and pieces of the attributes of the enterprise of integrated science. But most of their definitions limited the meaning of integrated science to dealing with one of these issue or the other. Only seven (12%) of the trainers had definitions embracing two of the categories. This narrow understanding shows that the teacher trainers like their trainee teachers and the secondary school teachers did not yet acquire a holistic view of the range of interests which integrated science stand for as embodied in the Nigeria Integrated Science curriculum and as reviewed in chapter three of this work.

11.3 TEACHER TRAINING FOR INTEGRATED SCIENCE AND THE SEPARATE SCIENCES.

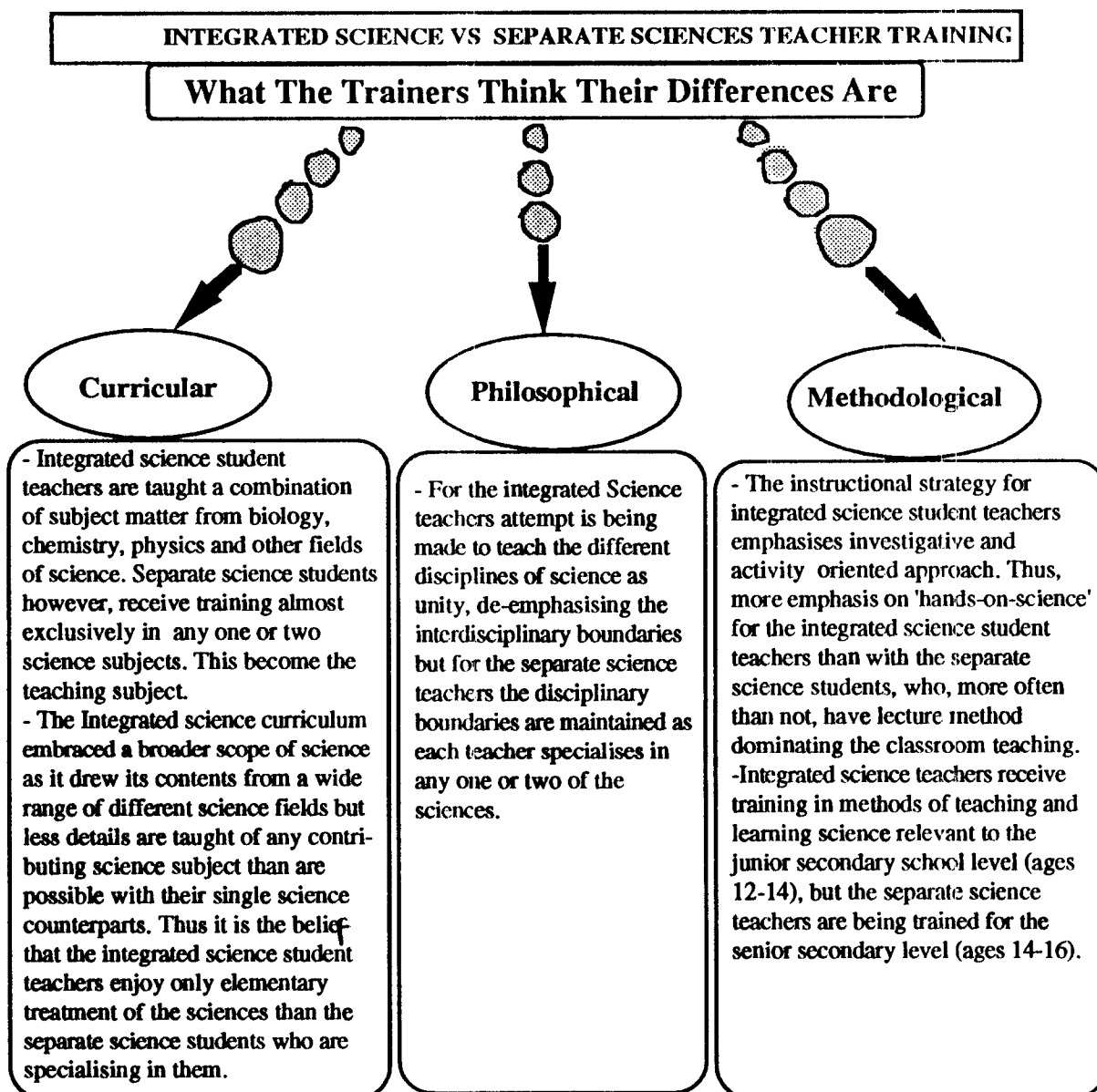
Teacher training for integrated science teaching at the junior secondary school and the separate sciences (biology, chemistry physics etc.) teaching at the senior secondary school, go on simultaneously within the institutions. The same cycle of trainers are involved in the training in both cases. An attempt was made here to find out what differences exist in the training programme of the two types of teacher training. The questionnaire demanded of the trainers to say, from their experiences, if there are any differences and to spell out what those differences could be. They were further required to list any three significant features of their training for integrated science teachers which they consider most important in enhancing the trainees' effectiveness for the job.

Responding to the differences issue in the teacher training for integrated science and the separate sciences, twenty two (37%) of the sixty trainers indicated that they saw no differences in the two types of training going on in their institutions. A typical respond by one of the trainers reads: *"I see no difference as the teaching of both courses does not differ in any particular way"*. Most of those who responded in this way did not say why they saw no differences in the two programmes even when the two programmes are distinct in their conception and target destination of products. The implication of the position taken to by some of these trainers is that even though the curriculum of the two training programmes

may differ significantly in design and philosophy, they hadn't notice any practical difference in the way both courses were being delivered. It's however quite difficult to say precisely why this number of trainers felt this way about these two programmes. Whether their position was a genuine expression of a fact that both trainings were, indeed, poorly organised and executed such that the trainers did not actually notice any difference or that because of their lack of any exposure to integrated science teaching and professional education. The latter reason is, however the likely inference from this research.

The remaining 38 (63%), a majority of trainers, see the two programmes as essentially different. The highlighted differences by the trainers have been classified here as: **Curricular; Methodological; and Philosophical** (figure 11.1).

Figure 11.1: Teacher trainers stated differences between the Teacher Training for Integrated Science and the Separate Sciences.



More than three quarters of the teacher trainers who listed these differences saw the differences purely as an issue of the contents of their curricula. Hence according to this group, the only difference between the integrated science teacher training and that for the separate sciences is in the fact that the former run a combination of different sciences in the curriculum while the latter specialises in any one or two of the sciences 'integrated' by the former.

Few trainers listed the philosophical and methodological differences. The credentials of this group of trainers revealed that they were not only professional science educators but have also benefited from some training to teach integrated science. On the other hand, most of those who saw the difference only as being curricular were mostly science graduates without education background and neither benefited from any course on integrated science teaching. They were therefore only stating the obvious.

Teacher trainers were further requested to list any three significant features of their training for integrated science teachers which they consider most important in enhancing the trainees effectiveness for the job. In other words the trainers were expected to list some competences hoped to be acquired by a student who go through their training course and build competence in handling the job of teaching integrated science in schools. Surprisingly, 33 (55%) of the 60 trainers did not attempt to respond to this question, most of these were the non-professional science educators. All the same, a couple of trainers with this background who have gone through some training for integrated science teaching, gave very impressive responses. There was even a significant number of science education graduates in this non-response group, many of these, however, indicated that they hadn't any experience on integrated science teaching.

The responses of the remaining 45% trainers offered the following range of competences which they believe their student teachers would acquire in the course of their training to teach integrated science effectively:

- understanding of the meaning and philosophical basis for integrated science, the JSS curriculum and its translation into lesson units;
- mastery of reasonable subject contents (knowledge) from the fields of science and the awareness of methods/resources needed for teaching;

- the concept of integration is well addressed, de-emphasising disciplinary boundaries and attempt to present a holistic view of science;
- acquire competence in teaching science by enquiry (investigative) and activity base approach;
- develop scientific attitudes and competence in the scientific process skills and manipulative skills;
- acquire competence in improvisation using locally available materials;
- rich educational background on how children learn science;
- acquire skills of classroom presentation through practical teaching; and
- capability of curriculum development and course materials.

This reflects a range of competencies which are very much identical to those offered by the course coordinators(see Network analysis, figure 8.2, page 181).

In an attempt to find out what problems the integrated science training course might be facing, the teacher trainers were, more or less requested to assess the programme and list, from their personal experiences, any three things considered as bottle-necks to the smooth running of the integrated science teacher training. In other words, their observations were to count as the weak points of the teacher training course. They were however required to conclude this section by further describing ways they think their training programme could be improved for best results.

Problems listed, as with the classroom teachers and student teachers, relate to the **curriculum, personnel, facilities/materials and enrolment(admission)**. The details are as follow:

- Lack of purpose-built laboratories and even when available they are often ill-equipped. Most laboratories do not have the services of technicians/technologists particularly needed to assist the trainers in organising practical exercises;
- Lack of textbooks and library facilities;
- A majority of the teacher trainers lack the necessary training and experiences to participate effectively in the programme;
- Massive curriculum content that encourages rushed work than a careful and meaningful teaching. This is particularly worst in institutions where integrated

science still flourishes as a single major (combining it with another discipline); **NB:** only one college was found to run the single major in integrated science. The time constraint for curriculum coverage has been more severe for the part-time programme than for full-time. This is due largely to the irregularity in the academic calendar caused by the incessant unrest that has characterised Nigeria over the years.

- The admission standard is quite low, as even candidates with eminently weak results in the pre-requisite sciences or even worst still, some with none of the required basic sciences background, were admitted into the programme. This made teaching of the basic science contents tedious and most often such weak students tend to find the course difficult to cope with. On the other hand, there is the difficulty in finding qualified candidates to enrol for the course; the reason being that such qualified candidates resist putting in for the course fearing that a career in integrated science has a 'dead end' - that is, its graduates will be restricted to teaching only at the junior secondary school level. Secondly, they are at the same time apprehensive of what the future holds for those who have ambitions for further academic career in integrated science bearing in mind the already existing apathy shown by a number of Nigerian universities towards introducing degree courses in integrated science.

The following suggestion were offered by the teacher trainers as ways the training programme could be improved:

- employing and mounting intensive training workshops for the teacher trainers particularly to familiarise them with the meaning, philosophy and teaching strategies for integrated science;
- provision of purpose-built laboratories where necessary as well as equipping them reasonably;
- review the curriculum to fit the time scale of training as well as reviewing the admission standard/policy to match the demand of the course and maintain a reasonable student-teacher ratio for effective teaching and classroom management;
- provide relevant textbooks and library facility;

- make all pre-service teacher training for integrated science full-time in order to lay a good foundation which is less likely with the part-time programme often suffering regular interruptions from irregularities in the yearly academic sessions. These incessant disruptions, usually from unrests, have in the past had a lot of negative effect on such part-time programmes with the result that the students are rushed through the course. Consequently, the products of the part-time programme tend to graduate more disadvantaged than their full-time counterparts.
- phase out single major integrated science course in favour of the double major course.

11.4: TEACHER TRAINERS' UNDERSTANDING OF THE CONCEPTUAL MEANING OF INTEGRATED SCIENCE AND WAYS IT COULD BE TAUGHT IN SCHOOLS.

The teacher trainers questionnaire, like those for the practising teachers and the student teachers, presented the trainers with the same list of sixteen statements about integrated science. Eight of the statements, referred to in this research as 'descriptors', reflect points of views about the meanings of integrated science while the remaining eight are pedagogical statements describing ways integrated science could be taught in schools. The statements were checked by the respondents to show their understanding of the meaning of integrated science in schools in Nigeria. However, while the student teachers and the practising teachers responded to the statements with 'agree', 'disagree' or 'undecided' to show their understanding of integrated science, the teacher trainers responded with 'relevant', 'neutral', 'unsuitable' and 'undecided'. Responding in this way to the given statements by the trainers was not only to show their understanding of integrated science, but in addition, to reflect the trainer's consent to the item as a relevant curriculum issue for teacher training in integrated science (see Appendix C[ii]). Responding with 'relevant' to an item means that it fits the trainer's personal view of integrated science and the statement could therefore constitute an important element of the curriculum for teacher training in integrated science. A response with 'neutral' shows that the statement is not a strong subject matter of integrated science and therefore viewed by the trainer as neither supportive nor obstructive to the training of integrated science

teachers; hence it may or may not be included in the curriculum. The response 'unsuitable' suggests that the trainer does not agree with the statement as a subject matter of integrated science and therefore, in his opinion, unsuitable for inclusion in the curriculum for integrated science teacher training. 'Undecided' means that the status of the statement cannot be determined.

The responses of the teacher trainers are presented in tables 11.2 and 11.3 below. The tables made numerical presentations of the trainers' responses relative to their background qualifications and experiences with integrated science. In particular, the variables considered in analysing the trainers' responses includes their professional qualification, that is, whether respondent is a science educator or not, whether trained in integrated science or not. Hence, in respect of these variables, the 60 respondents were categorised into the following four categories:

- Professional Science Educator with Training in Integrated science (PSE/T);
- Professional Science Educator without Training in Int Science (PSE/NT);
- Non professional educator with Training in integrated science (NPE/T);
- Non professional educator without Training in integrated science (NPE/NT)

Table 11.2: Teacher Trainers' understanding of Integrated Science and Relevant Curriculum issues for its Teacher Training.

Integrated Science Descriptor	Teacher Trainers Responses (Frequency. & %)			
	Relevant	Neutral	Unsuitable	Undecided
A. The acquisition of basic knowledge in the basic natural sciences and the earth sciences	60(100)	-	-	-
B. The development of scientific attitudes.	58(96)	1(2)	1(2)	-
C. Exploring the fundamental unity in all scientific knowledge.	60(100)	-	-	-
D. Understanding the conceptual unity of the sciences.	58(96)	1(2)	-	1(2)
E. Develop competence in the unified scientific process skills.	53(88)	5(8)	1(2)	1(2)
F. Exploring the relationship of science and technology.	54(90)	3(5)	3(5)	-
G. Science courses should have strong links with environmental education.	43(71)	12(20)	4(7)	1(2)
H. The awareness of the limitations of science as a basis for dealing with moral and political problems	51(85)	7(12)	1(2)	1(2)
Integrated Science Pedagogies				
I. Class discussion of social issues related to science should be considered an important type of school science lesson.	53(88)	5(8)	2(3)	-
J. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	45(75)	13(21)	1(2)	1(2)
K. Science schemes should be developed on a suitable psychological theory of learning.	47(78)	8(13)	4(7)	1(2)
L. A guided discovery approach to establishing concepts and generalisation should be used.	34(57)	15(25)	9(15)	2(3)
M. Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum.	39(65)	12(20)	7(12)	2(3)
N. Team teaching is an effective way of teaching integrated science.	46(77)	5(8)	6(10)	3(5)
O. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of an particular contents.	36(60)	13(21)	4(7)	7(12)
P. Students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics.	35(58)	16(27)	5(8)	4(7)

The result in table 11.2 shows that the integrated science descriptors(A-H) were highly regarded by the teacher trainers as important subject matters for integrated science. With the exception of item G, which recorded only about 70% acceptance and 20% apathetic (neutral) to it, all the items recorded as high as between 85-100% agreement. This high relevance level attached to these items by the trainers also suggests, in the

opinion of the trainers, that they are important issues that can be included in the integrated science teacher training curriculum.

The integrated science pedagogical statements (I-P) were not as highly acclaimed by the trainers as the descriptive items (A-H). That is, fewer trainers showed clear convictions about the relevance of even fewer pedagogies that could be accepted as useful methods of teaching integrated science in schools. Only four of the items (I, J, K and N) were widely agreed to (between 75-88%) by the trainers, while the remaining four (L, M, O, and P) recorded between 57-65%. This response to the pedagogies, therefore, means that the teacher trainers believed strongly that:

- the organisation of science lessons to discuss science-related social issues;
- taking into account the everyday life of the students in the selection of aims for science courses;
- developing science schemes based on a suitable psychological theory of learning;
- engaging in team-teaching,

are all very important and effective ways integrated science might be taught in schools. Least support ($\leq 60\%$) was given to items L(a guided discovery approach to establishing concepts and generalisation should be used) and P(students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics). This same result was observed from the responses made by the student teachers. However, in the case of the teacher trainers, when their responses were observed against their background qualifications and experiences (table 11.3), it was observed that the low support(rating) for the items in particular, arose almost exclusively from the following two categories of trainers:

- the non professional science educators with no training in integrated science (NPE/NT);
- professional science educators with no training in integrated science (PSE/NT).

Table 11.3: Teacher Trainers' Response Pattern to Integrated Science Descriptors and Pedagogies by Qualification and Training in integrated science.

ITEM	RELEVANT										NEUTRAL										UNSUITABLE										UNDECIDED									
	D E S C R I P T O R S																																							
	PSET	PSENT	NPET	NPE/NT		PSET	PSENT	NPET	NPE/NT		PSET	PSENT	NPET	NPE/NT		PSET	PSENT	NPET	NPE/NT		PSET	PSENT	NPET	NPE/NT		PSET	PSENT	NPET	NPE/NT											
A	20	23	2	15		-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-											
B	20	22	2	14		-	1	-	-		-	-	-	-		-	-	-	1		-	-	-	-		-	-	-	-											
C	20	23	2	15		-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-											
D	20	22	2	14		-	1	-	-		-	-	-	-		-	-	-	-		-	-	-	-		-	-	1	1											
E	20	22	2	9		-	1	-	-		-	4	-	-		-	-	-	1		-	-	-	-		-	-	-	1											
F	18	21	2	12		1	2	-	-		-	-	-	-		-	-	-	3		-	-	-	-		-	-	-	-											
G	19	14	1	10		1	7	-	-		-	4	-	-		-	2	-	2		-	-	-	-		-	-	1	-											
H	18	20	1	12		1	3	-	-		-	3	-	-		1	-	-	-		-	-	-	-		-	-	1	-											
P E D A G O G I E S																																								
I	18	22	2	11		1	-	-	-		4	-	-	-		1	-	-	1		-	-	-	-		-	-	-	-											
J	16	20	1	8		4	3	1	5		1	1	1	2		1	1	-	2		-	-	-	-		-	-	1	1											
K	18	19	1	9		1	2	1	4		1	1	1	2		1	1	-	2		-	-	-	-		-	-	1	1											
L	16	15	1	3		3	7	-	5		1	3	2	3		1	3	2	3		-	-	-	-		-	-	2	2											
M	16	15	1	7		1	4	-	7		1	4	1	1		1	4	1	1		2	-	-	-		-	-	-	-											
N	20	16	2	9		-	3	-	2		-	2	-	-		-	2	-	4		-	2	-	-		-	-	1	1											
O	18	14	1	3		2	3	-	8		-	2	-	2		-	2	-	2		-	4	-	-		-	-	1	2											
P	17	11	1	6		2	9	-	5		1	2	-	2		1	2	-	2		-	2	-	-		-	-	1	2											

PSE/T (Professional Science Educator with training in Integrated Science).-

PSE/NT (Professional Science Educator with no training in Integrated Science).-

NPE/T (Non professional Science Educator with training in Integrated Science).-

NPE/NT (Non professional Science Educator with no training in Integrated Science).-

n = 20
n = 23
n = 02
n = 15
N = 60

The general impression given by this result in table 11.3 was that teacher trainers who hold professional training in education or without and have not received any training in integrated science teaching, tend to respond more with either 'neutral', 'unsuitable' or 'undecided' to the integrated science 'descriptors' and 'pedagogies' than their counterparts who had received training in integrated science. The pattern of responses to the integrated science 'descriptor' items(A-H) by the various categories of trainers displayed in table 11.3 tends to give support to this. The relative percentage proportion of the respondents in each category responding either in the 'neutral', 'unsuitable' or 'undecided' are summarised below:

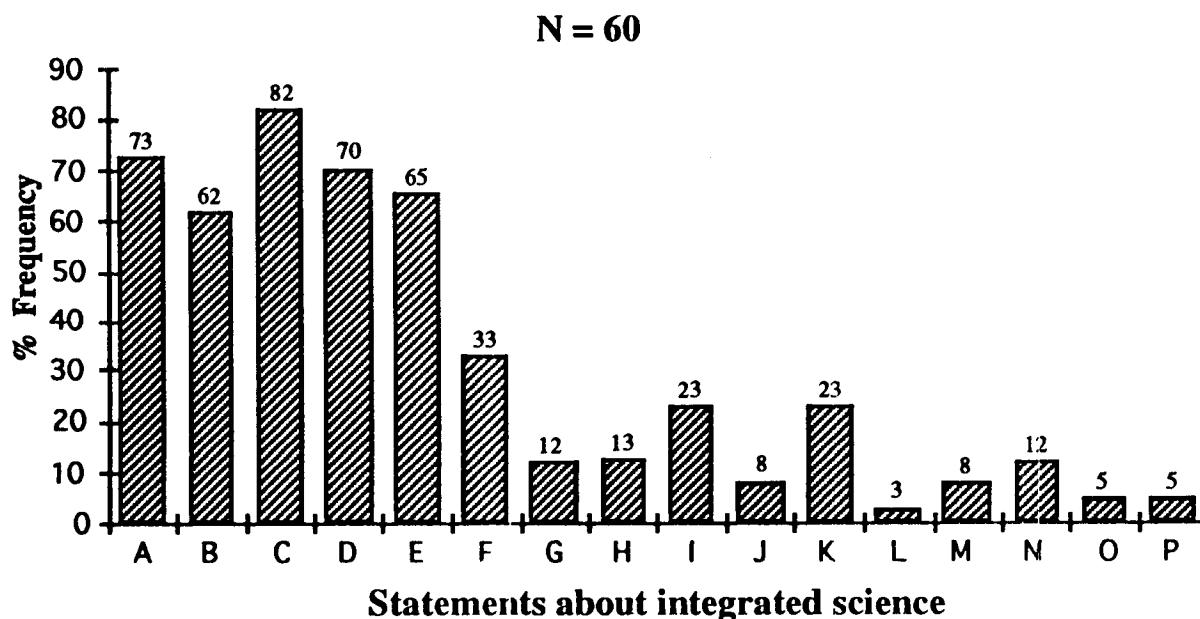
- only 15% and 5% trainers in PSE/T category responded with 'neutral' and 'unsuitable' respectively;
- 56% and 9% trainers in the PSE/NT category responded with 'neutral' and 'unsuitable' respectively;
- one of the two respondents in the NPE/T category was 'undecided' for 2 of the items;
- 60%, 33% and 13% in the NPE/NT category responded with 'neutral', 'unsuitable' and 'undecided' respectively.

On the other hand, the result for the pedagogical items show the following:

- 50% trainers in the PSE/T category checked 'neutral', 25% and 10% responded with 'unsuitable' and 'undecided' respectively;
- 74% from the PSE/NT category responded 'neutral', 26% for 'unsuitable', and 17% were undecided;
- the two respondents in the NPE/T category responded 'neutral' and 'undecided' in two pedagogies each. Only one of them remained 'undecided' for two other items;
- 93% of trainers in the NPE/NT category checked 'neutral', 60% for 'unsuitable' and 33% were 'undecided'.

The trainers were further asked to make a selection of any five statement from the items A-P which they considered most essential in describing the meaning of integrated science in schools. The result of choices made is represented in figure 11.2 below.

Figure 11.2: Teacher Trainers choice of five statements that best describe the meaning of integrated science in schools.



The teacher trainers' selection of five statements that best describe the meaning of integrated science in school (figure 11.2 above) showed that only statements A-E were highly subscribed to with over 60% each. This means that the trainers believed that the main concern of integrated science in schools are:

- exploring the fundamental unity in all scientific knowledge;
- the acquisition of basic knowledge in the basic natural sciences and the earth sciences;
- understanding the conceptual unity of the sciences;
- developing competence in the unified scientific process skills; and
- the development of scientific attitudes.

The choice of what the teacher trainers saw here as important in describing the subject matter of integrated science in schools represent the broader view about the range of interests being catered for by integrated science. All the same when the trainers were requested in section 11.2 to make personal descriptions of what they understand by

'integrated science', none of them offered a descriptions that was broad enough as to embrace a range of these interests. Attempts to interview some of the trainers proved difficult, especially with the non professional science educators, as most of them evaded me with some flimsy excuses of referring me to the staff of the faculty of education or those concerned with coordinating the programme. Even those who tried to respond to interview question about what they think of the integrated science programme, gave me the impression that they were involved with the teaching of elementary science programme to weak students who couldn't cope with the demand of the regular science programmes. Despite this attitude, their choice of what they regarded as important statements describing the meaning of integrated science in school were quite impressive; at least their choices demonstrated that they were able to recognise or guess what could constitute the subject matter of integrated science but, perhaps, could not interpret what exactly such statements stand for in the context of integrated science.

CHAPTER 12

DISCUSSION

Integrated science is the basic compulsory science subject taught in the three years of Junior Secondary School (JSS) education in Nigeria. However there has been sufficient evidence from research over the years that there is a mismatch between the training of teachers (NCE or degree holders) who teach integrated science and what they are required to teach (Odubunmi, 1981, Olarewaju, 1983; Balogun 1984; Jegede 1983, 1989; Maduabum, 1991 and Akinmade, 1988, 1992). The mismatch is that teacher training in Nigeria has been based on study of the separate sciences with the result that teachers trained under the system find it difficult to cope with demand of the integrated approach to science teaching and tend to emphasise in their teaching the disciplines in which they feel most confident.

This research sought to establish the current practices in the training of teachers for integrated science teaching in Nigerian schools, by revealing through the eyes of the participants the characteristics, quality and appropriateness of the training in fitting the teachers to their job of teaching integrated science.

In specific terms, the study sought to determine:

- the characteristics of the preservice and in-service teacher training for integrated science in Nigeria;
- the relevance and usefulness of the teacher training programme to the students for their roles in schools, bearing in mind the background of the students entering the programme;
- the congruity between the concepts of integration used in the integrated science core curriculum for the junior secondary school and that for teacher training;
- the perception of "integration in science" in schools held by classroom integrated science teachers, student teachers and the teacher trainers; to compare and contrast their views.

Data were sought to answer the following questions:

1. What are the main characteristic features of the integrated Science teacher training programmes in the teacher training institutions in Nigeria?
2. What is the integration pattern portrayed in the teacher training curricula and the junior secondary school curriculum; is there any relationship?
3. How is the concept of 'integrated science' understood by all participants, that is, the classroom teachers, student teachers and the teacher trainers?
4. How do the same participants perceive ways integrated science might be effectively taught and learnt in schools?
5. How do these participants see their training programme in terms of relevance and usefulness in meeting the needs of integrated science teaching in schools in Nigeria?

To address these questions data were collected by means of questionnaires and interviews from the integrated science course coordinators, teacher trainers, classroom teachers and the integrated science student teachers. The data was presented and analysed in chapter 8, 9, 10 & 11 .

12.1 REVEALED CHARACTERISTICS OF TEACHER TRAINING.

The 'characteristic features' of a training in the context of this research has been described in chapter 8 as concerned with the:

- entry requirement for candidates wishing to be trained for integrated science teaching
- selection process for admitting the candidates for the course;
- level of education for which the teachers are being trained (i.e. target for graduates of training);
- total experiences of the student teacher in terms of the taught contents (sciences, educational studies and pedagogical courses).

The result of the data analysed in section 8.1 of chapter 8 in respect of the admission requirement for the integrated science teacher training programmes showed that all the institutions stipulated credit passes in all the basic sciences (biology, chemistry and physics) for any candidate to qualify for admission. This would appear to be an essential requirement if the component parts of the subject matter to which the trainees are being exposed to is largely made up of these sciences. This is evident in table 8.2 page 177 and the curriculum analyses done in chapter 6 page 117 .

In the final selection process of the candidates for the course, almost all the institutions depended on the review of the application forms and the evidence of qualification (s) enclosed. No interviews were conducted to assist in determining the suitability of the candidates especially of the candidates' preparedness, conviction and understanding of the implication for their choice. This interview step is considered to be particularly important as it would help in selecting the most qualified candidates not only in terms of paper qualification but also in their show of interests and potentials for the chosen profession. On the other hand it must be recognised that the presumed admission procedure expressed here is that which is likely to give the best result when operated under a more ideal situation. The ideal situation here refers to the availability of enough applicants seeking places for a course. This is not the case with those seeking places for the integrated science course such that the training institutions experienced perpetual shortage of applicants even to the extent that persuasion is a frequent tool to recruit more candidates to enrol for the training. Under this prevailing situation, it is presumed that the training institutions see the strict scrutiny of applicants involving interview process as trivial and not worth the material expenses and human cost involved. The temptation that is likely to emerge from this situation is that the training institutions tend to even relax their admission conditions extending to the academic qualification of the candidates.

Contrary to the expected science background of the admitted candidates, the analyses of the students teachers' entry background (chapter 10, section 10.1, figure 10.3 page 211) revealed that the student teachers have very weak background in the pre-requisite basic sciences. This is a case of students who were admitted with marginal passes (low grades instead of high grades) in the required basic sciences. For instance, of

the final year students training for the Nigeria Certificate of Education at the Colleges of Education sampled for this research, 63% had biology, 59% had agricultural science, and only 30%, 9% had chemistry and physics respectively. A typical student then was one with biology/agricultural science background. For the university undergraduate student teachers, the case was not different; a typical student had biology/chemistry combination (figure 10.4 page 212). In both cases many of the students admitted for the course did not possess the stipulated requirement in its strict sense. This is not an impressive starting point for some one taking a career prospect in integrated science that has a heavy demand to learn biology, chemistry and physics. The point is that a prospective candidate of integrated science should be qualified in the basic sciences or at least studied them at the secondary school level. This was not the situation found in this study rather most of the student teachers had seriously deficient background in these basic sciences not only that they failed passing them in the O/Level examinations but many did not even study some of the sciences. More revealing was the students' responses to the questionnaire and interview questions which sought to reveal any cases of dissatisfaction with their training. It was understood that some of the students were recruited into the integrated science teacher training programme, a course they neither applied for nor were interested in . Such students were those who applied for single science courses but were found to be unqualified for their choices or cannot be accommodated and were therefore 'dumped' into the integrated science programme. Such students however, made unwilling acceptance of the offer and of course, painfully sacrificing their interest for security of any course since the offer now appeared to be the only available opening for fulfilling their ambitions for further education.

This situation brings to light two things going wrong with the integrated science teacher training programme: firstly, there is evidence that many inappropriately qualified candidates (both in academics and interest) were being trained; secondly, there seems to be a prevailing wrong understanding and attitude towards integrated science by the authorities in the training institutions which is greatly undermining the programme. To such people, integrated science has probably been conceived as a "second best" type of science designed for those who cannot cope with separate science disciplines. Certainly

this attitude has to change and integrated science must come to be considered as an important science of its own standing designed to fulfil some obvious science education philosophy; and that it is the most appropriate form of science teaching adopted for pupils in the junior secondary school. This means that integrated science must be given equal recognition alongside other components of the school curriculum. Serious consideration need not only to be given to the status of integrated science, but of the teachers being trained. The barriers to better training of teachers of integrated science arise from the status and future of its graduate teachers. The dilemma that haunts the student teacher and the practising teacher of integrated science is that of the career prospect in integrated science and the almost total confinement to teach at the JSS level, that is, no promotion prospect. They see themselves as venturing into what could be described as a 'close-ended professional field'. The point here is that integrated science is seen first and foremost as a non discipline and so there can be no further professional growth for those interested in pursuing in-depth disciplinary qualifications. While this is possible with other science disciplines, integrated science cannot provide motivation. Secondly, the fact that integrated science education has a status only at the junior secondary school level and all the teacher education programmes going on in the country should be to support the teaching of integrated science at this level. This being the case, its teachers believed that to train them purely and exclusively as integrated science teachers, is like caging them at the JSS level with all the derogatory stigma attached to integrated science by the public and colleagues who teach at higher levels.

Most of the training institutions for integrated science teachers believe that they were training their teachers to qualify for teaching integrated science at both the primary and the junior secondary school levels (ages 6-12 and 12-14 respectively). In the same way it was also claimed by the universities that their integrated science graduates were also to handle the training of other integrated science teachers at the colleges of education level. One thing is clear, the fact that integrated science education has a profound status at the junior secondary school level and only in recent years integrated science began to find its way into the primary school classrooms. In spite of the spread, it has never been claimed or implied anywhere that the implementation of the JSS integrated science is a

success story, rather the reverse is the case. The dearth of relevantly trained integrated science teachers is a major contributing factor. It is therefore quite worrying and confusing when training institutions hold such ambitiously broad objectives for their training programmes. The ambitious expectations for their graduates to be able to cope with teaching integrated science at the primary school level and other levels for which their training did not provide for, is quite unreasonable. This is particularly so when one considers the fact that not only do the syllabuses, teaching and learning styles differ at the different school levels, the needs of the students also vary significantly with age and experiences. Given this unfocused training objective by the institutions, one wonders how well prepared are these teachers to cope with the wide expectations. The implication is that they might not even be well prepared for their primary role at the junior secondary school level which raises further doubts about their effectiveness in discharging their duties. This might as well be a point for the training institutions to sharpen their training objectives to focus on the different levels of integrated science.

Turning to the issue of the total training package which the student teachers of integrated science go through in the course of their training, it was revealed that the integrated science training curricula have been developed from a substantial synthesis of subject matter, principally from biology, chemistry and physics (table 8.2 and figure 8.1). Other disciplines/fields of study also included in include earth and space sciences, environmental sciences, mathematics, health science and science & technology. The manner in which these contents have been arranged(integration pattern) in the curriculum is discussed in the next section (section 12.2). The distribution of credit units for the colleges of education curriculum components show that the science component has about 60% of the credit units, educational studies has about 20%, while science pedagogies and teaching practice hold about 10% each. A comparison of the credit units of the NCE curriculum components of the colleges of education and those of the university degree programmes (figure 8.2, page 177) showed that the integrated science course at the university level has higher work load than the colleges. However the teaching practice exercise is given more significance at the colleges than at the universities as indicated by the allocation of low credits to it at the universities. In general, it appears, more

importance is attached to students spending more time on theoretical knowledge at the expense of practical teaching. This situation of de-emphasising or playing down the importance of teaching practice in the training of a teacher may well lie at the heart of the problem of inadequately trained teachers. Practical teaching must be seen as an important and an integral part of the training of a teacher, this is particularly relevant for integrated science in developing and perfecting some skills where a wide curriculum coverage is required.

Figure 8.2, page 181, is a network analysis of responses to the questionnaire and interview questions by the course coordinators on what they thought were the abilities and skills intended to be developed in their trainee teachers of integrated science. The network, more or less a summary of the total experience for the integrated science student teachers, further highlighted three domains of abilities expected to be developed in the trainee during the training. The outline of the abilities, as appear on this network is quite comprehensive and would be reasonably sufficient in imparting the expertise necessary to cope with the effective teaching of integrated science. However, the ideas which have been synthesised in the network are those of the course coordinators; it is certain that few teacher trainers participating in the programme hold this same understanding about the training as was revealed from their reaction to similar questions (chapter 11, section 11.3). If this is the case, it then meant that the network gives only a theoretical picture of what the course coordinators and some of the trainers thought should be happening in their training classroom. It must also be pointed out that no single coordinator showed evidence of holding a holistic view of the range of competencies represented in the network and neither was any trainer able to represent his ideas in this way. Indeed less than a half of the trainers were able to give responses fitting the network analysis (see section 11.3 pages 229 - 234).

12.2 TEACHER TRAINING AND THE JSS INTEGRATED SCIENCE CURRICULA ANALYSED.

The integrated science curricula for teacher training at the Nigeria Certificate of Education (NCE) and degree levels and that for the Junior Secondary School (JSS) for which the teachers were being trained to implement were analysed. The objective for this exercise was to enable the researcher understand, may be subjectively, the **Meaning, Scope and Intensity** of integration in science demonstrated (explicit or implicit) in the curricula. The concept of integrated science, as discussed and observed in chapter 3 of this research, is a very complex one; one which grows slowly and communication gaps exist. Integrated science is a term that came into general usage after the UNESCO Congress on the Integration of Science Teaching held in Varna, Bulgaria in 1968. This was not just a new term for what had been known as general science, it was a new concept of what was needed in a science curriculum. The Varna Congress discussed the need to bring school science education closer to science as it actually is. The emphasis was on the philosophy and sociology of science. Blum (1973) and Brown (1977) each attempted to classify various conceptions of integrated science in the first decade of the innovations. Somewhat later, Haggis and Adey (1978) reviewed trends and the diversity of curricula, world-wide as far as was possible, and uncovered a great variety of interpretations and applications.

12.2.1 Analysis of the JSS Integrated Science Curriculum.

The JSS integrated science curriculum was conceived and designed as a response to the fact that Nigeria, in common with most African states, has insufficient well qualified school-leavers in the sciences to meet the needs of an increasingly technological society. It was, therefore, designed with a wider objective of preparing more students for careers in science and technology. The integrating principles for the integrated science curriculum, specified by the curriculum document, were intended to produce a course which is relevant to the students needs and experiences; stresses the fundamental unity of science; lays adequate foundations for subsequent specialist study, and adds a cultural

dimension to science education (Fed. Min. of Education, 1985). The thematically-based integrated science curriculum has been adopted as the most appropriate form of science education for all students in the Junior Secondary School.

The analysis of the JSS curriculum carried out in chapter 6, examined the provision for the range of meanings for integration in science as:

- unity of all knowledge;
- conceptual unity of the sciences;
- processes of enquiry;
- social relevance of science;
- interdisciplinarity (scope).

The determination of the meaning of integration in the curriculum in terms of 'unity of all knowledge', was done by examining the fitness of the topics under their respective themes. The fitness of a topic, placed under a themes, was examined to see if it fitted logically(from common sense) into the range of knowledge expected to appear under such an overall theme. The six socially appealing themes (**You as a living thing; You and your home; Living components of the environment; Non-living components of the environment; Saving you energy; and Controlling the environment**) do not appear to have been chosen to enable 'tight fits' of subject matter but are rather loose, accommodating a range of contents from a good number of disciplines. The themes and topics under them have been spirally arranged from the first to the third year of the JSS. The suitability of the topics/contents and their arrangement under themes and years of study (spiral arrangement) might have been largely influenced by commonsense notion of development of children and not by any specific theory of cognitive psychology of learning. At the time of this field work there was no evidence of the availability of a guide or any document for that matter, that could give insight into the integrating factors that guided the arrangement of subject contents under themes. Should this be the case, the question is, how does the teacher who implements the curriculum understand the intention of the curriculum developer? Certainly, leaving the teachers to just common sense interpretation of the curriculum could be misleading and holds a negative

implication for the entire programme. The tendency is that teachers just teach moving from topic to topic in no particular order and without making links.

The analyses for the provision of integration in the JSS curriculum in terms of 'conceptual unity of the sciences', 'processes of enquiry', 'social relevance' and 'interdisciplinarity' in chapter 6, section 6.3 (page 123) revealed that there is significant attempt to reflect them in the curriculum. With the exception of integration in terms of the 'conceptual unity of science' which has been sparingly reflected, all the other four show extensive evidence of provision in the curriculum. The curriculum in particular showed considerable interdisciplinary scope, drawing its contents from a wide range of disciplines (see table 6.5(b) and figure 6.1). Subject contents integrated were found to have been drawn mainly from biology, chemistry, technology, health science, earth/environmental sciences and agricultural science. Thus, there is evidence that the curriculum was designed to:

- draw on everyday experiences and take account of different stages in the child's development;
- provide a balanced science curriculum which stresses the unity of science content and processes;
- lay an adequate foundation for subsequent study in science and technology;
- provide a basic understanding of the role and function of science and technology in everyday life;
- relate to the differing environmental conditions found in Nigeria.

The intensity of integration in the JSS curriculum fits reasonably Blum's (1973) '*amalgamated*' category. He defines an '*amalgamated curriculum*' as one in which an interdisciplinary topic or issue forms the unifying principle.

The result of the analyses has shown that the Nigeria Integrated Science core curriculum for the junior secondary school compared to those for its teacher training has a unique and reasonable concept of integration. That is, it is easy to identify from the JSS curriculum the deliberate attempts made to integrate knowledge from different disciplines conforming to the general concepts of 'integration in science' reviewed in chapter 3.

12.2.2 Patterns of integration in the Teacher Training Curricula.

The teacher training curricula examined were those of the Nigeria Integrated Science Teacher Education Project (in use at the Colleges of Education) and for two universities.

The NISTEP curriculum in use at the colleges of education, although fashioned in the form of courses, had themes (titles) around which subject contents were built. It has a thematic approach with spiral arrangement similar to the design in the JSS curriculum. The use of themes for the courses were attempts to provide for the meaning of integration as 'unity of knowledge'. However, unlike the more interdisciplinary themes used in the JSS curriculum, the NISTEP curriculum is clearly less interdisciplinary as such themes(titles) were selected reflecting specific science disciplines from which they have been taken. For instance, it is easy to tell that a theme like 'statics & dynamics' is of physics origin; 'carbon compounds' is from chemistry while the title 'transport, control, skeletal system & development in living things' is biological. Similarly, contents under each of these themes reflect, almost entirely, the characteristics of these disciplines. With this characteristics, the NISTEP curriculum fits Blum's description of a '*combined curriculum*' category. This is when a science programme would involve developing chapters or organising other major units round headings taken from the different disciplines. The design of the curriculum in this way is not surprising as this was made to fit the teaching pattern of the integrated science courses in the colleges of education. The various science departments in the college handle the different courses relative to their expertise.

In providing for the meaning of integration as 'social relevance of science', the NISTEP curriculum was found to show very high prominence (appendix F). That is the content of the curriculum contained a large amount of information considered important for the student's better understanding of science and its implication for himself, his home, his environment, his culture as well as his society and country.

For integration in the NISTEP curriculum via the conceptual schemes and/or major concepts, very little attempt has been put in this direction. Even with an explicit intention that the curriculum will make constant reference to unifying concepts such as

energy, conservation, balance and cycle in nature etc. there is little evidence of this intention in the design of the curriculum. This 'silence' would as well be taken to mean that the job of realising integration in this way largely lies with the teachers of the course who have to use more of their initiative in recognising and deciding when it's appropriate to do so as they attempt to implement the curriculum. In fact this low prominence in featuring integration via major concepts and/or conceptual schemes in the NISTEP curriculum is similar to the observation made in the JSS curriculum. It has been claimed by Abah, (1991) that this phenomenon of low prominence is strongly suggestive of the possibility that strategies aimed at achieving maximum integration as the "social relevance of science" may technically repress the chances of achieving full integration as the "conceptual unity of the sciences" and vice versa in the same curriculum.

The NISTEP curriculum shows a wide scope of interdisciplinary integration involving the physical sciences, biological sciences, earth sciences, mathematics, and technology; drawing more heavily on biology, chemistry and physics than the other disciplines. There are also reasonable number of themes/topics (e.g. man and energy; man in the environment; environment and population; science and society etc.), which centre on the utility of science (the social relevance of science), which is another important facet of integration in science. The trend reflected in the scope of integration and provision for the social relevance of science in the NISTEP curriculum is quite similar to that of the JSS curriculum. There are noticeable differences only in the intensity (depth and breadth of contents) and style of integration. Indeed it is expected that the teacher training curricula should have a greater intensity than that which the teachers are being prepared to implement. For the assumption is that the more knowledgeable teachers are, the more confidence they have in themselves and their teaching, hence the need to expose them to broader and in-depth study of the discipline they will be teaching in school.

The teacher training curricula in use in the two universities have their contents designed completely in the form of modular course units with no deliberate attempt to portray integration through thematic approach (unity of all knowledge). That is to say the content of the courses are seen and taught as separate packets of knowledge and process with little over-lapping content with other courses. These courses which have been drawn

directly from their originating parent departments, have a few of them arranged spirally. The only pattern of integration that is clearly identifiable in both curricula is the 'interdisciplinarity' (scope)-drawing from several disciplines and the 'social relevance of science'. Other meanings of integration like the 'conceptual unity of the sciences' and the 'processes of scientific enquiry' feature more prominently and separately in the methodological and pedagogical courses. In other words they are given more or less theoretical treatment in the department of education. This means that the students have more opportunities of being taught about what they are rather than getting opportunity of being engaged into the enquiry process and learn how they are through contents. This sharp division in the training process can hardly be believed to offer much opportunity of a practical experiences to the students. Furthermore this research suggests that most of the professional scientists participating in the teacher training lack adequate background in education as well as relevant experiences with integrated science teaching. This makes it more difficult to think that such trainers can make the concept of integration more real and practical (where possible) in their teaching of the science contents to the students which would certainly benefit the students more. It is not being suggested here that the professional scientists should also be seen to take responsibility of teaching the pedagogical aspects of the curriculum; it will be unreasonable as it would certainly be making too much demand (work load) on such trainers. But the case being made here is that because of the special and unique nature of integrated science in schools, trainers of teachers should be more informed and sufficiently armed with the special needs of the training. If this has not been the case, then it might as well be difficult to hold in confidence that the products of such a training would really understand and teach the subject of integrated science in the very best perspective. The trainees are most likely to perceive integrated science and ^sif/teaching in the same manner as those having the most influence in their training; in this case, the professional scientists whose course work take about 60% of the training. For teachers, it is said, teach as they themselves were taught. Nonetheless by this line of reasoning, it must be stressed that it shouldn't be construed here that the author intended to give the impression that the teaching of the integrated science should be an exclusive business of the professional science educators in the

departments of education, but rather pointing to the more crucial need to train every participant in the relevant skills.

12.3 PERCEPTION AND UNDERSTANDING OF INTEGRATED SCIENCE BY STUDENT TEACHERS, PRACTISING TEACHERS AND THE TEACHER TRAINERS IN NIGERIA.

The research attempted to obtain from the integrated science practising teachers in schools, student teachers and the teacher trainers in colleges and university departments of education their perception and understanding of integrated science in schools in Nigeria. This was thought to be important as it was hoped to signal any disparity between the intended (as in the curriculum) and its implementation (as indicated by the understanding of the participants).

Personal definitions of integrated science given by these participants and analysed in chapters 9(section 9.2 page 195), 10(section 10.2, page 213), 11(section 12.2, page 228) showed that they perceived and understood integrated science in the following ways and in order of popularity (see also figure 9.6 page 201):

- a subject which teaches a combination of subject matter from the basic sciences of biology, chemistry and physics in particular; and other scientific fields in general;
- an approach to the teaching of science as unity, stressing the interdisciplinary relationship and de-emphasising the traditional boundaries between science disciplines.;
- a subject which teaches about the scientific attitudes and process skills;
- teaching about man and the environment;
- teaching about the living and non-living things;
- a subject which teaches about the world/universe.

Defining integrated science as "a subject which teaches a combination of contents from the biological and physical sciences as well as a measure of some other scientific fields" was most popular among all the groups of respondents irrespective of their qualification, training and teaching experience. The popularity of the first definition on the list is a finding that is quite similar to results of some earlier researches undertaken to

find out how pre-service and in-service teachers of integrated science in Nigeria understand and teach integrated science in schools (Olaewaju, 1983; Jegede, 1983; Akinmade, 1988b, Maduabum, 1990; Nkpa, 1991). This result is quite an unimpressive progress as even after a decade not much has changed from the understanding held about integrated science by teachers of integrated science. The understanding of integrated science in this way did not even differ with qualification, training and experiences of the participants. This is to say that even those who claimed to have benefited from some sort of training to teach integrated science did not show any significant departure from this view that integrated science as merely concerned with teaching combined contents of biology, chemistry and physics. Nonetheless defining integrated science as in categories 2&3 above were more popular among school teachers and teacher trainers who were professional science teachers, had training to teach integrated science and had many years of teaching experience. Similarly it was only teachers with this type of background that offered definitions of integrated science reflecting broadly the range of interest covered by the subject. Teacher trainers who were non-professional science educators show less understanding about the main concern of integrated science by either offering no definition at all or showing very narrow understanding, popularly of the type in category one above. Perhaps because of this preponderance of less qualified integrated science teacher trainers, the student teachers (who were then final year students), could not, as did most of their trainers, demonstrate any more impressive perception and understanding of integrated science. This finding that the integrated science teacher training institutions had more less qualified staff (by training and experience), makes it difficult to believe that the graduates of such a training could be any better prepared for their job at the secondary or elsewhere. Indeed the definitions of integrated science by the students analysed in section 10.2 showed similar trend of understanding as those of their trainers.

The research further presented all the participants with two sets of summary statements (extracts from literature) - see table 12.1 below. In one set, "integrated science Descriptors", each statement reflects a point of view about the meaning of integrated science and in the other, "integrated science Pedagogies", they reflect point of views about ways integrated science might be effectively taught in schools. The respondents

were instructed to respond to these statements to further show their understanding of the conceptual meaning of integrated science and ways they thought it might be taught in schools. Details of responses within groups are analysed in sections 9.4, page 203; 10.4, page 220 and 11.3, page 235.

Table 12.1: Popularity of statements describing the meaning of integrated science ('Descriptors') and ways it might be taught in schools ('Pedagogies') among the student teachers, practising school teachers and the teacher trainers.

Integrated Science Descriptor	POPULARITY OF STATEMENTS (FREQUENCY & %)		
	Student Trs.. N = 144	School Trs N = 52	Tr. Trainers N = 60
A. The acquisition of basic knowledge in the basic natural sciences and the earth sciences	136 (95)	52 (100)	60(100)
B. The development of scientific attitudes.	135 (94)	50 (96)	58(96)
C. Exploring the fundamental unity in all scientific knowledge.	130 (90)	51 (98)	60(100)
D. Understanding the conceptual unity of the sciences.	123 (85)	47 (90)	58(96)
E. Develop competence in the unified scientific process skills.	128 (89)	44 (85)	53(88)
F. Exploring the relationship of science and technology.	119 ((83)	45 (86)	54(90)
G. Science courses should have strong links with environmental education.	93 (65)	46 (88)	43(71)
H. The awareness of the limitations of science as a basis for dealing with moral and political problems	132 (92)	21 (40)	51(85)
Integrated Science Pedagogies			
I. Class discussion of social issues related to science should be considered an important type of school science lesson.	131 (91)	26 (50)	53(88)
J. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	121 (84)	45 (86)	45(75)
K. Science schemes should be developed on a suitable psychological theory of learning.	121 (84)	40 (77)	47(78)
L. A guided discovery approach to establishing concepts and generalisation should be used.	86 (60)	49 (94)	34(57)
M. Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum.	104 (72)	30 (58)	39(65)
N. Team teaching is an effective way of teaching integrated science.	111 (77)	34 (65)	46(77)
O. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of an particular contents.	108 (75)	41 (79)	36(60)
P. Students should be engaged in analysing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics.	57 (40)	37 (71)	35(58)

Contrary to the way the respondents showed their understanding of integrated science when asked to define it, their rating of the statements reflected more broad perception and understanding of integrated science than was possible in their personal definitions. However, a closer look at the pattern of responses did reveal certain noticeable traits embedded also in their personal definitions. For instance, the high choice of the statement "the acquisition of basic knowledge in the basic natural sciences and the earth sciences" by almost all the respondents as important and necessary in describing the meaning of integrated science matches closely the most popular definition of integrated science as "a subject which teaches a combination of subject matter from the basic sciences of biology, chemistry and physics in particular; and other scientific fields in general". Secondly, the popularity of the statements describing the meaning of integrated science among all groups of respondents (table 12.1 above) was in the following decreasing order:

- the acquisition of basic knowledge in the basic natural sciences and the earth sciences;
- exploring the fundamental unity in all scientific knowledge;
- the development of scientific attitudes and competence in the unified scientific process skills;
- understanding the conceptual unity of the sciences;
- exploring the relationship of science and technology;
- relevance of science to environmental education; and
- the awareness of the limitations of science as a basis for dealing with moral and political problems.

The trend shown in the rating of these statements reflects very closely to some extent, certain elements of compatibility with the categories of definitions developed out of the respondents' personal definitions represented in figure 9.5, page 197.

However, in their responses to the integrated science pedagogies, there was less unanimous pattern of agreement between the different groups of respondent as was with the 'descriptor' items. There were noticeable variations between the groups in their responses to the different items. The responses of the practising school teachers in particular were more varied from those of the student teachers and the teacher trainers which show more similarities across most of the items. Despite the variation, the relative

popularity of the items as effective methods of teaching integrated science in schools shows that two items (J&K in table 12.1 above) were highly and unanimously agreed upon by over 70% each of the three groups of respondents. Although responses to the rest of the items varied widely, the responses to many of the items by the teacher trainers and their students in particular seems to show similar level of support relative to that shown by the school teachers. This phenomenon could probably be attributed to the influence of the trainers on the student teachers.

When the responses were further examined against other variables of the respondents such as their qualification, gender, training in integrated science, and teaching experience, the following observations were made:

- student teachers who hold the General Certificate of Education (from secondary education) show higher tendency to agree with the statements describing the meaning of integrated science, than the holders of the Grade II Teachers' Certificate (from teacher training college for primary education) -see table 10.3b. By the nature of their curriculum, those with secondary school education background should have been more exposed to science disciplines than their counterparts from the teacher training colleges. This finding seems to suggest that there is a more positive relationship between a GCE background and a good chance of excelling in integrated science education. In other words, students with background in secondary education are likely to be better prepared for integrated science education than holders of the Grade II Certificate. In any case it could not be concluded strongly here that the observed difference in their responses is a sole factor of this difference in background.

The reverse was the case in the responses to the pedagogical statements; that is holders of the Grade II Certificate agreed more to the pedagogies than did the GCE holders (see table 10.4b). This difference could be related to the very fact that the Grade II teachers' Certificate holders had the advantage of having gone through professional training to teach in primary schools before embarking on this further teacher training for the secondary. They would have been familiar with the principles and practices in education to place them on an advantage of making more

sense of these pedagogies than their GCE colleagues (training for the NCE in particular) who were encountering professional teacher training for the first time.

Male students also tend to agree more highly with both set of statements than their female colleagues.

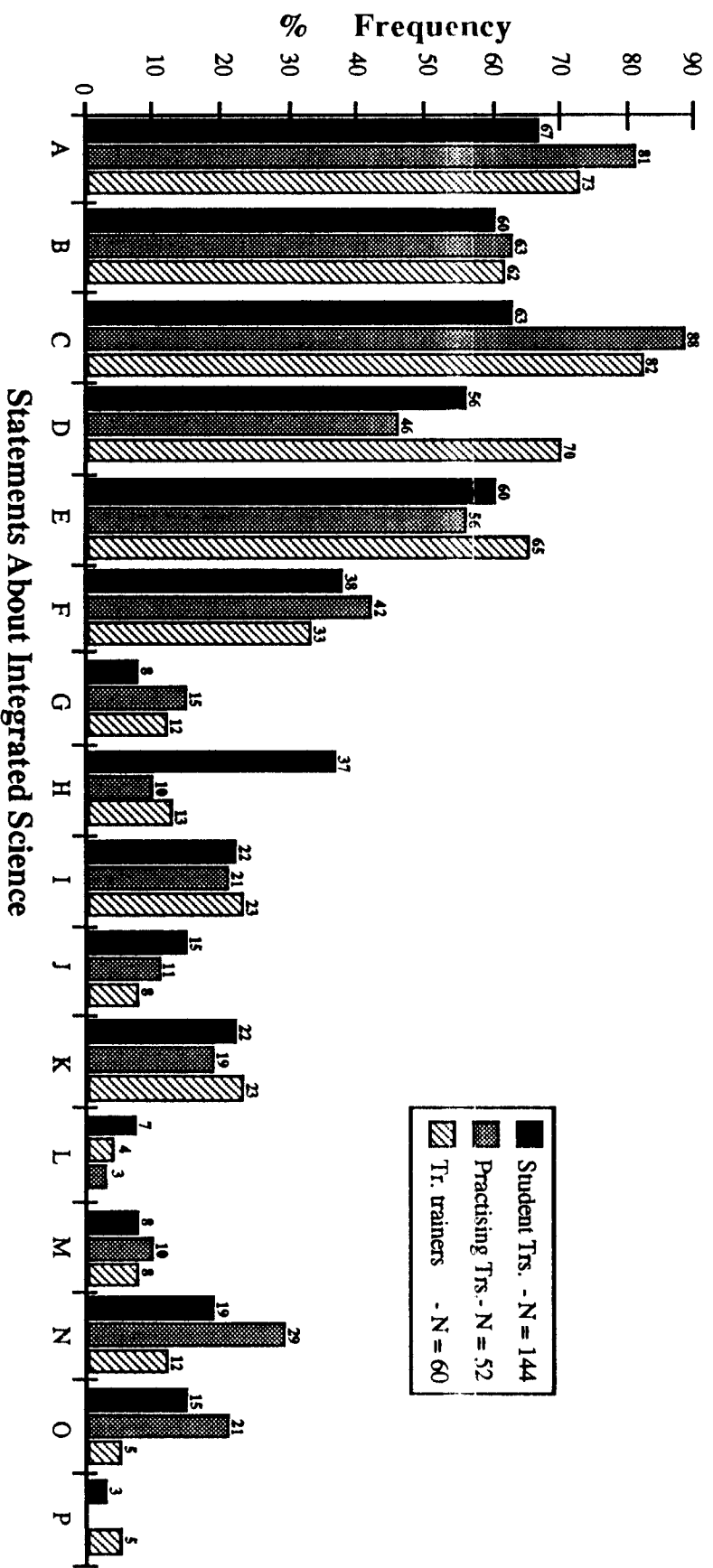
- Teacher trainers who were either professional or non-professional science educators but have had no any form of training for integrated science teaching show low perception of the relevance of the statements (A-P) in describing either the meaning or ways integrated science might be taught in schools. But trainers who have enjoyed training in integrated science, no matter their qualification, showed more positive support for the statements.

Of the sample of sixty (60) teacher trainers, only 15 (25%) were females and less than half of them claimed to have had any training in integrated science. There was however no evidence of the gender factor having any influence on the trainers' pattern of responses other than the factor of training in integrated science.

The preponderance of the untrained teacher trainers in all the training institutions sampled in this study has an obvious negative implication for the whole integrated science programme in these parts of the country and Nigeria at large. That the student teachers would not be relevantly trained means that when the job for which they were being prepared is placed in their hands, other objectives other than those which the designers of the curriculum intended are pursued.

The student teachers, practising teacher and teacher trainers were given the chance to choose from the list of sixteen statements about integrated science any five which in their opinion best describe the meaning of integrated science in schools in Nigeria. The result of this exercise is presented in figure 12.1 below (see also figures 9.9, page 207; 10.6, page 224 & 11.2, page 241).

Figure 12.1: The choice of five statements that best describe the meaning of integrated science in schools made by the student teachers, practising teachers and teacher trainers.



The picture given by figure 12.1 suggests quite strongly that the choice of five most important statements that best describe the meaning of integrated science in schools was unanimous for all the three groups of respondents. Apparently items A, B, C, D & E were the most highly favoured of the sixteen statements. This means that student teachers, practising teachers and the teacher trainers agreed on the following statements as best describing the meaning of integrated science; the list is in order of popularity of the items:

- exploring the fundamental unity in all scientific knowledge;
- the acquisition of basic knowledge in the basic natural sciences and the earth sciences;
- the development of scientific attitudes;
- develop competence in the unified scientific process skills.
- understanding the conceptual unity of the sciences;

No doubt, this choice presents an impressive description of some of the broad interest integrated science is intended to serve. Indeed, large proportions of the respondents subscribed to each of these statements as meaningful in describing the range of interests integrated science caters for. Whether this broad perception of the issues of concern for integrated science represent real understanding or just intelligent guesses on the part of the respondents, the fact remains that the choice largely did not match the perceptions shown by their personal definitions of integrated science. It is more likely that many of these participant (especially those that had no training or orientation on integrated science) have some fair ideas about the subject that probably influenced such meaningful choice and may not necessarily be an evidence of any real understanding. In any case, whether their choice here represent real understanding or not, the phenomenon tells the story that a reasonably large number of the integrated science participants did recognise valuable elements of integrated science education.

12.4 RELEVANCE AND USEFULNESS OF INTEGRATED SCIENCE TEACHER TRAINING PROGRAMME AS ASSESSED⁵ BY THE PARTICIPANTS.

The research attempted to find from the personal opinion of the student teachers, practising teachers and teacher trainers on the programme of teacher training for integrated science teaching. For the student teachers and the trained practising teachers, they assessed the general *adequacy*⁶ of the training (received or being received) in helping them perform their role of teaching integrated science effectively in schools. To this end both groups were provided with three categories of response (Good; Fair; and Inadequate) with which to sum up their training experiences. Although summing their opinions in this way did not tell us much about the quality of training, we gained, at least, a knowledge of how the participants were feeling which will motivate a more close and in-depth future study. While almost all the practising teachers assessed their training experiences as "Fair", the students teachers varied with their institutions and the type of training programme being followed. Most students receiving training in the university departments of education and from the colleges of education pursuing the NISTEP programme rated their experiences as "Good" (see figure 10.5, page 214). Their response in this way was hardly surprising as the NISTEP colleges have benefited immensely from the project facilities and expertise. They were therefore relatively more established and stable in terms of staff quality and perhaps in also infrastructural facilities than any other institutions in the country. Most students of other colleges assessed their experiences as "Fair". In a follow-up interview with some of the students it was further discovered that their use of "fair" to describe their experiences was only but a cautious and polite way of expressing their unhappiness with the programme. They were in fact finding the course uninteresting and difficult. The students generally believed that some of the problem areas of their training includes ambitiously massive curriculum, lack of relevantly trained trainers, lack of laboratories/basic equipment and lack of relevant textbooks. These problems were also raised by some teacher trainers and practising teachers. While these

⁵ - Assessment describes the participants' expressed personal opinions on how they generally feel about the training programme; issues considered, among others, includes the curriculum, staffing, the teaching and facilities.

⁶ - The *adequacy* of training was to be seen in terms of confidence built in knowledge and methods.

problems could be genuine it must be admitted here that the list represents a rather more general and common experiences in the teaching and learning in science classroom in Nigeria and not just exclusive to integrated science. These general problems notwithstanding, it was observed (table 10.1, page 215) that students whose basic qualifications was the GCE were more likely to rate their training experiences as 'good' than the holders of the Grade II certificate. This to say, student teachers with the Grade II certificate found the integrated science course more difficult than their GCE counterparts.

The teacher training curricula in use at the time of this research (Appendices G, H, I), also analysed in chapter 6 have been described as "massive" by some of the respondents, giving the impression of an overloaded curricula. Although a curriculum by nature is not a perfect document and therefore is subject to revision from time to time, those under question in this research appear to be overloaded. Although the curricula might look ideal considering the background of the students entering the training programme, it is at the same time unrealistic in the light of the training duration and the needs of the students. As evidence of curriculum overload, teacher trainers said that they were not having enough time on the school time table for an effective coverage of course work. Consequently there was always "crashing" through the work with perhaps, very little concern for the students need and the objective of the training. The delivery of the course in this way was hardly unexpected as most of the teacher trainers lack the relevant training, especially the participating professional scientists. There was also a general feeling among the trainers that the whole training programme had not been taken seriously as most of the admitted candidates hold either no qualification in science or had weak backgrounds. There was therefore doubt being cast on the success of the training to fulfilling its objectives given also other operating bottle-necks.

In summary, it seems that some of the bottle-necks of the training programme include:

- curriculum overload which at the same time does not appear to be appropriately matched to the course duration and to the needs of the student teachers;
- the teacher trainers are not experienced in integrated science, teacher training, and teaching in schools;

- poor recruitment procedures for candidates; and
- the status problem for the teachers of integrated science in schools who are undervalued not only by the public but even by the educational system and other colleague science teachers.

How to deal with these problems have been discussed and suggestions are made in the next chapter for improving the teacher training programme in colleges and universities.

CHAPTER 13

CONCLUSION AND RECOMMENDATION.

The main thrust of this research was to establish the practices that go on in the training of teachers of integrated science in Nigeria. This was done by examining the relevant curricula and obtaining the opinion of the participants in order to establish the characteristics, quality and appropriateness of the training in fitting the teachers to their job of teaching integrated science in schools.

Integrated Science is the first basic and systematic science course taught as a compulsory subject in the three years of Junior Secondary School education in Nigeria. This has been running for over two decades but, until recently (late 1980s) there was no deliberate plan for its teacher education. There was then almost a total mismatch between the training of the Nigerian Certificate of Education (NCE) and university science graduate teachers and what they were required to teach in integrated science in schools. The training of such NCE and university graduate teachers were based on the separate sciences and, as a result, the new integrated science course was not taught effectively in schools.

It was not until late 1980s when some institutions in Nigeria saw the need to mount relevant teacher training for those who would teach integrated science in schools. Most Colleges of Education in the country were running the 'single major' courses in integrated science, that is, combining integrated science with one other science discipline. With the recent establishment of a National Commission for Colleges of Education, a board responsible for the academic programmes of all colleges of education in Nigeria, integrated science has become a 'double major' course with a National core curriculum (Appendix G). Of the over thirty universities in Nigeria, only about ten are known to offer training courses for teachers of integrated science while many remain apathetic to it. Perhaps the most laudable effort in teacher training for integrated science that also started in the late '80s is that of the "Nigeria Integrated Science Teacher Education Project" (NISTEP). Based in ABU, Zaria, NISTEP was started with the objective to, among

others, improve the effectiveness of integrated science teaching by developing a programme to train teacher trainers (lecturers in the colleges of education) to teach integrated science effectively to the student teachers studying on the NCE programme; develop a double major integrated science programme for use in ABU's affiliated colleges; and assist in the eventual development of a Bachelor of Education (BEd) programme in integrated science at ABU. The NCCE has adopted the NISTEP curriculum and being implemented in all colleges of education throughout the country.

This study has attempted to analyse not only the NISTEP curricula now being implemented as a 'double major' in all colleges of education in Nigeria but also the curricula for some two universities also involved with the training of integrated science teachers at the degree level. In addition the study also obtained testimonies from the student teachers, practising teachers, teacher trainer and the training coordinators on the nature, relevance and usefulness of the integrated science teacher training programme

In the light of the research findings, their discussions and implications, the following conclusions are made:

13.1 CONCLUSION.

1. The analysis of the Junior Secondary School Core-curriculum for integrated science revealed a substantial amount of evidence to show that it was designed to:

- draw on everyday experiences and take account of different stages in the child's development;
- provide a balanced science curriculum which stresses the unity of science content and processes;
- lay an adequate foundation for subsequent study in science and technology;
- provide a basic understanding of the role and function of science and technology in everyday life;
- relate to the differing environmental conditions found in Nigeria.

The design of the teacher training curricula has placed more emphases on the acquisition of the scientific subject matter than of any other aspect of teacher training. This is clear

from the composition of the courses (largely dominated by pure science teaching) as well as the manner in which these courses are being delivered. That is, the science is not taught as integrated but as separate science and solely by means of lectures. This contrasts with the competencies and skills identified as necessary for a competent integrated science teacher.

2. Many student teachers saw their training curricula as overloaded, not appropriately matched to the duration of their training and needs.
3. There is a fundamental flaw with the integrated science enterprise in Nigeria which is related to the general attitude held by both the public and academics about integrated science and the effect it has on the current teaching in schools, the admissions and training of its teachers. Integrated science is being conceived as a "second best" type of science designed for those who cannot cope with separate science disciplines. This derogatory and negative attitude appeared to have had some profound influence not only on the way teachers were being assigned to teach integrated science in schools, but was also being perpetuated in the admission procedures and training of its teachers in the training institutions. Practising teachers in schools were found to be the least qualified and inexperienced of all science teachers; if the teacher had any science qualifications at all, they were likely to be only in the life sciences. In addition many student teachers undergoing training to become integrated science teachers were found to hold very weak backgrounds in the pre-requisite sciences. Although the policy statements on admission specified some high standard for the selection of candidates, the admission officers in colleges and universities appear to lack the conviction and will to implement it strictly and seriously. This "status problem" of integrated science has a direct but negative effect on its teachers who are consequently under-valued even by their fellow science teachers. Furthermore, the status and more importantly, the career dilemma of integrated science teachers, those with more qualified science background are unwilling to be trained as integrated science teachers. They see integrated science as

possessing no future career prospect in any science discipline but merely caging its victims to a permanent teaching career at a low level, that is, the JSS level.

4. As regards the meaning and operational definition of integrated science, relevant to the curricula in schools and teacher training colleges, the following five features of "integration" as it applies to integrated science teaching were established, namely:

- **as the unity of all knowledge** (portrayed by the choice of themes or titles under which topics or courses taken from different disciplines have been built);
- **as the conceptual unity of the sciences** (the attempt to integrate knowledge under great ideas of science such as energy, diversity, continuity, change etc.) - *NB: this meaning of integration showed least prominence in all the curricula examined;*
- **as a unified process of scientific enquiry** (portrayed by the attempt to teach or demonstrate the scientific process skills such as observation, classification, reporting, experimenting, predicting etc.);
- **as interdisciplinary study** (portrayed by the number of disciplines or fields of study drawn upon);
- **as the social relevance of science** (attempt to show either by mention, application or implication, the social utility of science).

In fact the full definition of integrated science provided by D'Arbon (1972) and the more streamlined definition provided in chapter 3 section 3.2.6, page 60 of this study, may be regarded as adequate operational definitions of integrated science for the Nigerian Integrated Science Project (NISP). Indeed these definitions are copiously reflected already in the philosophy and objective of the JSS core curriculum for integrated science as well as those for the teacher training.

5. In terms of the **meaning and scope** of integration, it was found that there was a reasonable match between the curricula for schools and those for the teacher training institutions. With respect to the scope of integration in the curricula, they drew their contents from a wide range of disciplines and fields of study. These among others, includes biology, chemistry, physics, geography, geology, mathematics, agricultural

science, health/environmental education, technology and cultural issues (in JSS curriculum in particular). The intensity of integration (extent to which the separate disciplines are blended) became progressively weaker as one went from the JSS curriculum, to the NISTEP curriculum, to those of the university departments of education. They more or less fitted Blum's intensity category descriptions of 'amalgamated', 'combined' and 'coordinated' curriculum respectively.

6. There is a serious dearth of relevantly trained integrated science practising teachers for the junior secondary schools and the teacher trainers in the training institutions studied in Nigeria. The shortage is both of quantity and quality. At the moment, the teacher trainers on the ground, were found to be inexperienced^d in integrated science, in teacher training, and in teaching in schools. The most laudable and well conceived contribution to the search for competent teacher trainers for integrated science is that by the Nigeria Integrated Science Teacher Education Project, based at the Ahmadu Bello University, Zaria, administered through affiliated colleges of education spread only in the Northern part of Nigeria. Of all the training institutions studied, it is only ABU that has had a fair share of trained integrated science teacher trainers through the NISTEP; however, regret^tably, most of these trained personnels were largely under-used or had nothing to do with the project any more when the researcher visited ABU.
7. Integrated science education has a important status at the junior secondary school level. However, most integrated science course coordinators in the training institutions gave weakly focused, but broad objectives for training teachers for integrated science. Moreover this focus was spread across the primary and secondary and in some cases, the colleges of education level. The position of the course coordinators was proved to be at variance with the stated objectives of their curriculum documents. This signalled a potential source of mismatch between the intention and the implementation and a vague notion about the level(s) at which their graduates would teach.

8. The age-long perception and understanding of integrated science as a subject merely concerned with the teaching and learning of mixed contents from the sciences, principally of biology, chemistry and physics is still the most popularly held view of integrated science by most student teachers, practising teachers and teacher trainers. Other issues that gained high support among all the participants as relevant in describing the meaning of integrated science and which the teacher trainers, in particular, strongly subscribed to as important curriculum matter for teacher training in integrated science, included:

- exploring the fundamental unity in all scientific knowledge;
- developing competence in the unified scientific process skills;
- the development of scientific attitudes; and
- understanding the conceptual unity of the sciences.

Despite the high consensus shown by the participants on the above issues, there was a substantially wide range of definitions of integrated science held by participants; most of these were either unclear or ambiguous. The following were some of the common definitions held of integrated science:

- a subject which teaches a combination of subject matter from the basic sciences of biology, chemistry and physics and other scientific fields;
- an approach to the teaching of science as unity, stressing the interdisciplinary relationship and de-emphasising the traditional boundaries between science disciplines;
- a subject which teaches about the scientific attitudes and process skills;
- teaching about man and the environment;
- teaching about the living and non-living things;
- a subject which teaches about the world/universe.

This calls for an urgent need to simplify the model of integrated science so that more can understand it and trainers need to be taught its meaning too.

9. Student teachers with background in secondary school science (GCE) appeared to be better prepared for the integrated science education than those whose background were in the grade II teachers' certificate. Similarly, the GCE and the Grade II certificate background qualifications notwithstanding, female students generally seem to find the integrated science training course more difficult than their male counterparts.

10. More student teachers from the NISTEP pilot colleges of education and university departments of education expressed satisfaction with the relevance and usefulness of their training for integrated science than was possible with students from other training institutions.

11. Most teacher trainers, irrespective of their professional qualification and level of involvement with the training, tend to assess the training as low-key, lacking the fundamental momentum for the project from the state and/or training institutions.

13.2: RECOMMENDATION.

In the light of the fore-going conclusions, the following recommendations are made:

1. There is urgent need to give priority to the training of teacher trainers as this relates directly to the effectiveness of teacher training for integrated science in these institutions. The impact of the Nigeria Integrated Science Teacher Education Project (although conceived and designed for implementation as a National project) has rarely been felt around the country. Although presently based at the Ahmadu Bello University, Zaria, it has so far been the only laudable and well coordinated step towards training of teacher trainers. For more positive results the need to decentralise this project to other colleges and universities around the country cannot be over emphasised. This process should be accompanied by fresh campaign for renewed vision for the training of teacher trainers. This can effectively be done through the

National Commission for Colleges of Education (NCCE), the Science Teachers Association of Nigeria (STAN) and the individual authorities of universities.

2. The admission of candidates to be trained as teachers of integrated science must be based on some sound policy and selection process that ensures the admission of suitably qualified candidates. It is suggested here that while it is necessary to place emphasis on candidates possessing sound foundation in the basic pre-requisite sciences, the interest and aptitude of the candidates must not be neglected. This points to the invaluable involvement of the interview in the final selection process of the candidates. However to attract more competent candidates and dispel the fears arising from the low status and career prospects of integrated science teachers vis-a-vis teachers of other science disciplines, it might be necessary to redesign the integrated science teacher training curriculum, at the degree level in particular. The design of the new programme might, for example guarantee career opening in other science disciplines for those who might develop such ambition. This could be achieved by running the initial teacher training for integrated science as a 'double major' only at the NCE level to be followed by, at least, a compulsory three year teaching of integrated science at the JSS level. After this tenure, qualified candidates wishing to pursue degree qualification in any science discipline at the university should be allowed to combine one science discipline of their choice with integrated science (modular courses in other sciences). In other word, both the double and single major courses in integrated science are to be run at the university.
3. It is necessary to change the attitudes of both the public and the educational system towards integrated science. It must be seen as the first systematic science course offered to pupils as few of them will have been taught through an effective primary science programme. For pupils continuing their education, it provides a base for further scientific study; and, to those whose education finishes at the end of the JSS stage, it offers a useful understanding of science and technology in everyday life. Integrated science, therefore, must come to be considered, from its science education

philosophy, as the most appropriate form of science teaching for pupils in the JSS and NOT as a "second best" type of science to be taught at this level because resources and equipment are in short supply. This means that its teachers and the teaching of integrated science must seriously be given a status it deserves coupled with an effective motivation and supervision by the Ministry of Education. The public must also be made to recognise the importance of integrated science through some sort of public enlightenment campaign programme.

4. Integrated science curriculum developers, teacher trainers and teachers in Nigeria should recognise that the scope and intensity of integration provided for in the JSS curriculum was found to reflect the following five features of "integration" as the word applies to integrated science, namely:

- as the unity of all knowledge;
- as the conceptual unity of the sciences;
- as a unified process of scientific enquiry;
- as interdisciplinary study;
- as the social relevance of science.

Is it recommended too that the Junior Secondary School integrated science curriculum in particular be reviewed to reflect (in the textual organisation) a more meaningful and clearer picture of these five features of integration in science. The six themes used in the JSS curriculum do not reflect 'tight fits' for a number of topics and contents built under each of them. While there were obvious cases of mis-fit observed, it was also not clear why some topics were placed where they occur and not somewhere else. In the opinion of the researcher, the choice of fewer themes (only six in the case of the JSS) as the fulcrum for integration has the advantage of achieving greater integration of topics and contents than if the themes were more numerous. However it becomes more imperative for the curriculum developers to provide an explicit guide to help teachers implement the curriculum the way it was intended. It is this sort of guide that is lacking for the JSS curriculum. There is need for it not just for the classroom practising teachers

in the schools but also for the teacher trainers and student teachers in the training institutions and this leads to better understanding of the purpose of science education and where it is leading to. The more the teachers are aware of the message and goal of a curriculum, the better their teaching and assessment strategies and procedures would be, to arrive at the target(s).

5. Since the scope of the JSS curriculum covers a broad range of disciplines and in the light of the observed preponderance of untrained teachers who were largely in charge of its teaching in schools, it is recommended that such teachers should be encouraged to use team teaching where necessary. However, as a priority, teacher training institutions in Nigeria as well as STAN should design and operate suitable INSET programmes for the re-orientation of such 'unskilled' serving teachers towards more effective teaching of integrated science. In this way the teeming population of secondary schools in Nigeria would not have to wait until an adequate number of graduates of the new NCE and B.Ed. programmes recently mounted are produced to teach the subject. There is also the urgent need for both the untrained teacher trainers and practising teachers who are already serving in training institutions and schools to be provided with some relevant amount of training in the philosophy and methodology of integrated science teaching. This is hoped not only to modify (or possibly change) their perception and understanding held about the subject as merely concerned with teaching of combined contents from biology, chemistry and physics but should assist them to be able to teach the subject meaningfully and with an integrated approach. We all know that the most threatening problem, most teachers would admit in their teaching, is that of being asked to teach a subject for which they are inadequately prepared.

6. On the support materials or facilities for teaching integrated science the following recommendations are made:

- Relevant text material for the students and teachers' guides for the teacher training curricula should be produced and made available to the institutions,

especially for the NISTEP curriculum which has been adopted for use in all colleges of education in the country.

- Government should make more finances available for the procurement of essential facilities, texts and guides which the individual students of institutions find quite difficult to procure because of their prohibitive commercial prices.
- Teachers should be encouraged to improvise what they can but ensure that what they improvise resembles the real thing as much as possible, both in structure and function. Again, this depends on the knowledge and skills of the teacher.

7. The teachers' wages and general condition of service must never be ignored or trivialised as it has been witnessed over the years that it is one important single factor that affects the zeal and morale of the teacher in his job performance. An observation made by Efa in this respect and reported in Bajah (1993) reads:

Teachers have seen a massive decline in their status; they are asked to work long hours for a salary that has rarely kept up with inflation; they often work with only a few materials of very poor quality; contact hours with their students are reduced; and more and more time is spent on needless administration brought about by constantly changing government policies.

It must be concluded here that no effort should be spared in the proper training of science teachers both at the initial and in-service stage. Desirable competences of an integrated science teacher have been exhaustively discussed in chapter 5, page 80. Enough well qualified teachers, it is said, are a sine qua non of successful curriculum implementation, as no curriculum material is teacher proof, deliberate effort must be made to familiarise the teacher with materials they are expected to use in the classroom. Experience has shown that no matter how well an education programme has been developed, the success in the final analysis depends on the classroom teachers.

13.3 LIMITATIONS OF STUDY.

The field work for this research was undertaken during the most critical point of the political crisis in Nigeria which did not guarantee the normal condition for data collection. This coupled with time and financial constraints, the data collected was limited only to institutions in the Northern part of the country. Hence much more caution was taken in the interpretation of some of the research findings with a consequent limited application and implication of such findings for the whole country.

The observations made of the NISTEP colleges in this study may not be generalised as only three of about 19 NISTEP colleges, spread over Northern Nigeria were sampled for this study.

Due to the behaviour of some respondents, the researcher also acknowledges the possibility of having obtained and made use of some data that might not be totally reliable. For instance, some respondents were too cautious when responding to questions requiring critical answers.

13.4 FURTHER RESEARCH.

It might be necessary to conduct a follow-up study on the performances of:

- (i) the NISTEP trained teacher trainers;
- (ii) the graduates of the new NISTEP curriculum.

The study is to be undertaken with a view to gaining information on the usefulness of the training. The information gained will not only serve as relevant indicators of the success of the training but will also provide useful data for any possible over-hauling of the curriculum and the training materials.

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Please Take Note of the following references:

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APPENDIX A

QUESTIONNAIRE VALIDATION REQUEST LETTER

Science Department,
Institute of Education,
University of London,
20 Bedford Way,
London WC1H 0AL.
16-6-1992

Dear Colleague,

VALIDATING A QUESTIONNAIRE FOR USE IN NIGERIAN COLLEGES/ UNIVERSITIES.

I am a Research Student (Ph.D.), undertaking a research on the training of teachers for Integrated science teaching in Junior Secondary Schools in Nigeria. The research will attempt to find out how the training is done, its relevance and adequacy in meeting the demands of the integrated science national core-curriculum for the Junior secondary schools. Specifically attempts will be made to find out:

1. the nature of the courses;
2. the aims and objectives of these courses;
3. opinions about them, particularly how effective they are in training teachers for Nigerian schools
4. views about the nature of integrated science held by teachers and students.

Attached is a questionnaire for the teacher trainers, one of the data gathering tools.

Please would you fill it as fully as you can. This will not only help me to check the responses anticipated in the actual study in Nigeria but will also enable me to carry out a trial analysis. Your responses will be handled in confidence.

Please return the completed questionnaires to Dr John May.

I would welcome the chance to meet with you in a later date to discuss your responses to the questionnaire. This would help me obtain feed-back concerning such features as:

- (a) length of questionnaire;
- (b) ambiguity or clarity of questions;
- (c) suitability of questions for teacher trainers in Nigerian colleges/universities;
- (d) omissions; and
- (e) any other suggestions.

Thanks for your cooperation and anticipated input in this research project.

Yours Sincerely,
SUNDAY N. WUYEP.
(RESEARCHER)

APPENDIX B

**LETTER OF INTRODUCTION SENT TO INTEGRATED SCIENCE HEADS
OF DEPARTMENT IN COLLEGES AND UNIVERSITIES IN NIGERIA.**

Dear Sir/Madam,

MR SUNDAY N. WUYEP - RESEARCH VISIT.

MR SUNDAY N. WUYEP is one of our Ph.D Research Students undertaking a research on the training of teachers for integrated science teaching in Junior Secondary Schools in Nigeria. The research will attempt to find out how the training is done, its relevance and adequacy in meeting the demands of integrated science National core-curriculum for the junior secondary schools. Specifically attempts will be made to find out:

1. The nature of the training courses.
2. The aims and objectives of these courses.
3. Opinions about them, particularly on how effective they are in training teachers for Nigerian schools.
4. Views about the nature of integrated science held by teachers and students.

Mr Wuyep is expected to undertake a field work to Nigeria where he shall obtain the necessary data for this research from schools, colleges and the universities. Your institution/department is among those that have been chosen for the purpose of this research exercise.

The visit to your institution/Department will involve the administration of questionnaires/interviews to:

- (i). H.O.D. Integrated Science and/or Integrated Science Course Coordinator (*Questionnaire & interview*).
- (ii). Teaching staff of the department (*questionnaire only*).
- (iii). Final Year Student Teachers (*questionnaire/interview*)

Mr Wuyep shall be arriving Nigeria in October, 1992 and will get in touch with as soon as possible. We are appealing to you to give him all the possible assistance he will require from you.

Thank you in anticipation for your cooperation.

DR A.D. TURNER (Supervisor)

APPENDIX C(i)

Integrated Science Teacher Education in Nigeria

Researcher: SUNDAY N. WUYEP

Science Department

Telephone : 071- 580 1122 Ext. 5777

Fax 071- 612 6126



**INSTITUTE OF
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UNIVERSITY OF LONDON

20 BEDFORD WAY

LONDON WC1H 0AL

Director SIR PETER NEWSAM

Deputy Director PROFESSOR PETER MORTIMORE

QUESTIONNAIRE FOR INT. SC. COURSE-COORDINATORS

This questionnaire is designed to help identify the characteristic features(course work and activities) that constitute the programme for the training of teachers in your institution for integrated science teaching.

Please respond as fully as you can. Your responses shall be treated confidentially and all information provided herein shall be used for the purpose of this research only.

SECTION A: FACTUAL BACKGROUND INFORMATION

1. Name of Institution_____

2.Address_____

3. Does your institution undertake any training for teachers of integrated science?

Yes ☐ No ☐

4. Is your programme Full Time ☐ Part Time ☐ or Both ☐

5. What type of certificate course does your programme offer?

(i) Postgraduate (Diploma or Certificate) ☐

(ii) Bachelor's Degree (B.Ed or B.Sc.Ed) ☐

(iii) Nigerian Certificate of Education (NCE) ☐

(iv) Others(Specify)_____

6. For which of the following educational level are the teachers being specifically trained?

(i) Primary

☐

(ii) Junior Secondary

☐

(iii) Grade II Teachers' College

☐

(iv) College of Education

☐

(v) Others(specify) _____

7. How many integrated science student teachers are training in your institution this 1992/93 academic session?

YEAR	Student number (Full Time)	Student number (Part Time)
ONE		
TWO		
THREE		
FOUR		
FIVE		

8. Please supply the following information about the graduates produced by your training.

Year	No. of Graduates	No. of students per result category					
		1 st class or Distinction.	2.1 or Credit	2.2	3 rd	Pass	Fail
1988							
1989							
1990							
1991							
1992							

SECTION B: ENTRY REQUIREMENT FOR CANDIDATES
--

9. What academic qualification(s) do you consider acceptable for entry to the integrated science course in your institution?

10. Do you interview applicants seeking admission before offering them places on the course?

Yes

☐

No

☐

11. If you do not interview the applicants, please state how you select students for the course.

SECTION C: THE INTEGRATED SCIENCE COURSE

12. Which science subjects are taught to the student teachers as part of the curriculum for integrated science training in your institution?

- | | |
|--|---|
| (i) Chemistry <input style="width: 40px;" type="checkbox"/> | (v) Geology/Earth sciences <input style="width: 40px;" type="checkbox"/> |
| (ii) Physics <input style="width: 40px;" type="checkbox"/> | (vi) Environmental Science <input style="width: 40px;" type="checkbox"/> |
| (iii) Biology(Bot. & Zoo.) <input style="width: 40px;" type="checkbox"/> | (vii) Health Education <input style="width: 40px;" type="checkbox"/> |
| (iv) Astronomy <input style="width: 40px;" type="checkbox"/> | (viii) Science & Technology <input style="width: 40px;" type="checkbox"/> |
| (ix) Others(please list) _____ | |

13. How much time is devoted to the different components of the curriculum?

COMPONENTS OF THE CURRICULUM	CREDIT UNITS/HOURS
Science contents	
Science pedagogies	
Educational studies	
Teaching Practice	
Others	

14. Do your students engage in out-of-class activities like visits to industries, field trips etc, as part of their taught courses?

Yes ☐ No ☐

15. If your answer to question 14 above is yes, please state the specific activities and the course with which it is associated.

ACTIVITY	COURSE ASSOCIATED WITH

16(i) What is the number of staff trainers participating in the training programme?

(i) How many of these trainers have science qualification?

(iii) How many of these teacher trainers are professional science teachers educators?

17. Do you consider your present staff strength as adequate in meeting the training needs of the course? Yes ☐ No ☐

SECTION D: RATIONALE FOR COURSE

18. Your integrated science programme seeks to train teachers for integrated science teaching in schools. Please state any three important characteristics of your successful students which fit them for this role.

(i)

(ii)

(iii)

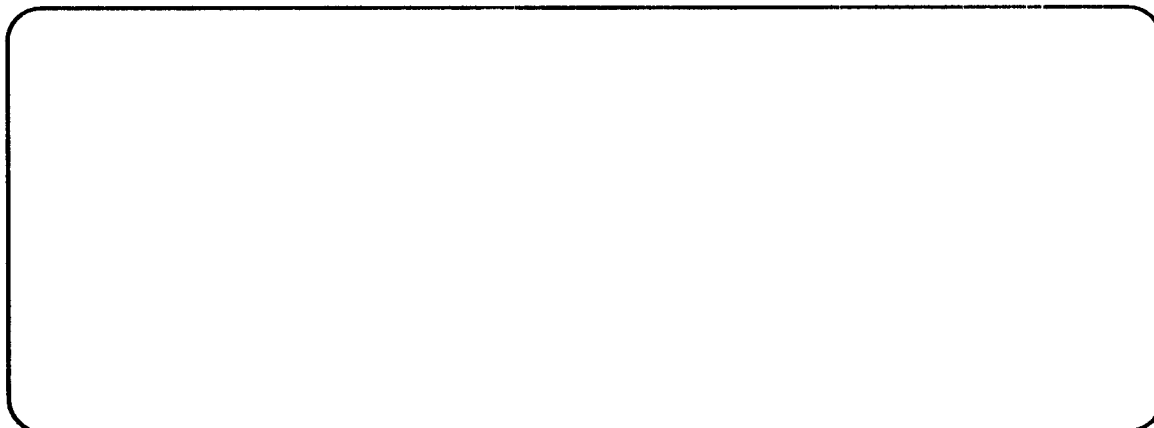
19. For each of the characteristic described in No.18 above, please indicate with a tick in the table below where on the course the characteristic mainly will be developed.

	Educational Studies	Subject Teaching	Pedagogy	Teaching Practice
(i)				
(ii)				
(iii)				

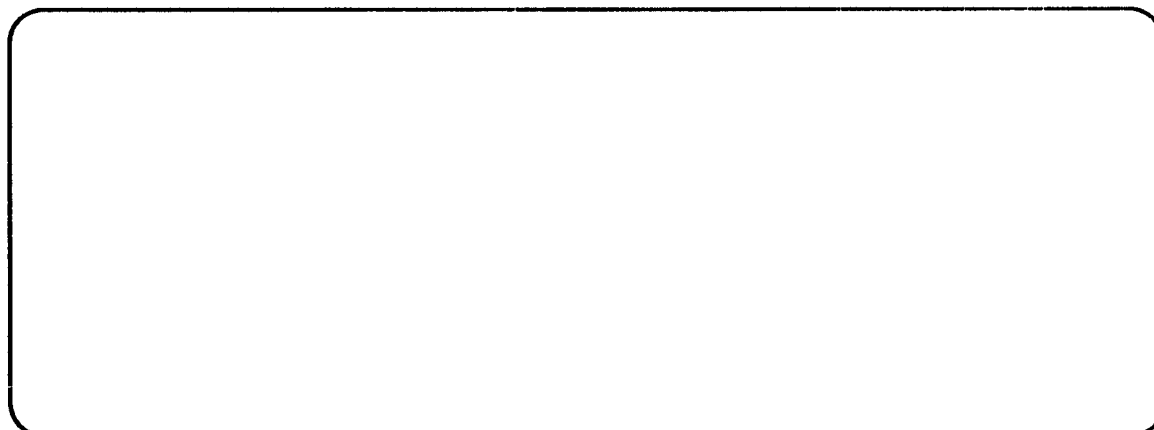
20. Please state any important feature(s) of your course which you think helps to develop the skills of teaching integrated science.

21. In what ways does the training of integrated science teachers differ from those of other science teachers(i.e biology, chemistry or physics teachers) in your institution? Please state these differences from the point of view of content studies, pedagogical studies and teaching practice as indicated below.

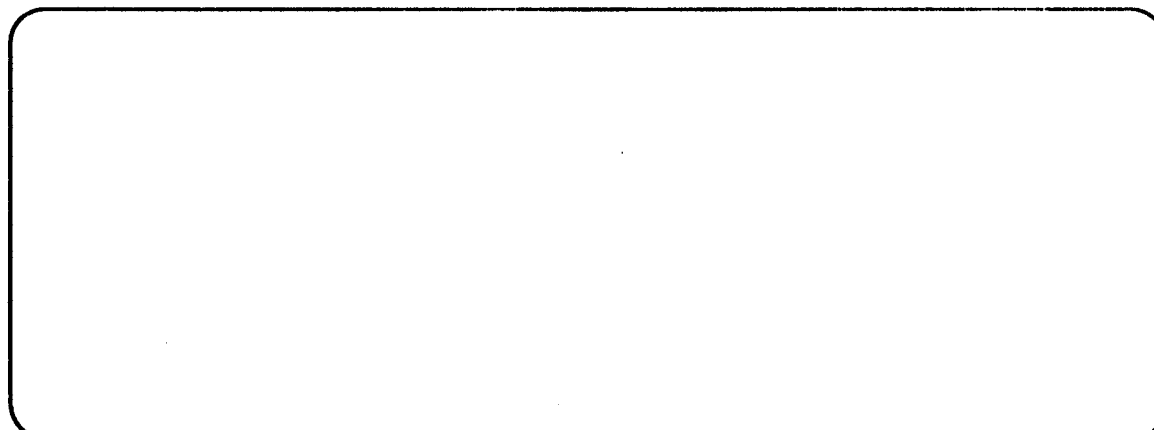
(i) Content studies:



(ii) Pedagogical(methods) Studies:



(iii) Teaching Practice:



APPENDIX C (ii)

Integrated Science Teacher Education in Nigeria

Researcher: SUNDAY N. WUYEP

Science Department

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**INSTITUTE OF
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Director SIR PETER NEWSAM

Deputy Director PROFESSOR PETER MORTIMORE

INTEGRATED SCIENCE TEACHER TRAINERS' QUESTIONNAIRE.

This questionnaire has been designed to help obtain the following information:-

(a) Your view of the nature of integrated science teacher education programme in your institution.

(b) Your perception of integrated science and those issues you consider relevant for inclusion in the curriculum for the education of teachers of integrated science in Nigeria.

Please respond to each item as fully as you can. Your responses shall be handled confidentially and the information provided shall be used for the purpose of this research only. Thank You.

SECTION A PERSONAL DATA

1. Your College or University _____ Dept. _____

2. Address _____

2 Sex:	Male	<input type="checkbox"/>	Female	<input type="checkbox"/>
3. Age Group:	20 - 24	<input type="checkbox"/>	40 - 44	<input type="checkbox"/>
	25 - 29	<input type="checkbox"/>	45 - 49	<input type="checkbox"/>
	30 - 34	<input type="checkbox"/>	50 - 54	<input type="checkbox"/>
	35 - 39	<input type="checkbox"/>	55 & above	<input type="checkbox"/>

4. Academic Qualification. *(Please indicate with a tick against any of the following qualifications that you possess)*

- | | | |
|-------------------------------------|--------------------------|---|
| (i) WASC/GCE | <input type="checkbox"/> | |
| (ii) Teachers' Grade II Certificate | <input type="checkbox"/> | |
| (iii) A'Level(IISC,IUMB,OND) | <input type="checkbox"/> | Subjects: 1 _____
2 _____
3 _____ |
| (iv) N.C.E. | <input type="checkbox"/> | Subjects: 1 _____
2 _____
3 _____ |
| (v) HND | <input type="checkbox"/> | Discipline _____ |
| (vi) B.Ed./B.Sc.Ed | <input type="checkbox"/> | Discipline _____ |
| (vii) B.Sc. | <input type="checkbox"/> | Discipline _____ |
| (viii) PGDE/PGCE | <input type="checkbox"/> | |
| (ix) M.Ed. | <input type="checkbox"/> | Discipline _____ |
| (x) M.Sc. | <input type="checkbox"/> | Discipline _____ |
| (xi) Ph.D | <input type="checkbox"/> | Discipline _____ |
| (xii) Others (Specify) | | _____ |

5. Status or Rank:

- | | | | |
|------------------------|--------------------------|--------------------------|--------------------------|
| (i) Professor | <input type="checkbox"/> | (iv) Lecturer II | <input type="checkbox"/> |
| (ii) Reader | <input type="checkbox"/> | (v) Lecturer III | <input type="checkbox"/> |
| (iii) Senior Lecturer | <input type="checkbox"/> | (vi) Assistant Lecturer | <input type="checkbox"/> |
| (iv) Lecturer I | <input type="checkbox"/> | (vii) Graduate Assistant | <input type="checkbox"/> |
| (viii) Other (Specify) | _____ | | |

SECTION B : EXPERIENCES

6. Which of these subjects were you taught during your post primary education?

- (i) Integrated Science ☐
- (ii) General Science ☐
- (iii) Both i & ii ☐
- (iv) None ☐

7 (a) Have you at any time taught at the secondary school level?

Yes ☐ No ☐

(b) If yes, for how long? Years

8. Which of the following science subjects did you teach at the secondary school level?

- (i) Integrated Science ☐
- (ii) General Science ☐
- (iii) Chemistry ☐
- (iv) Physics ☐
- (v) Biology ☐
- (vi) Others (specify) _____

9. Have you had any course or training for teaching integrated science?

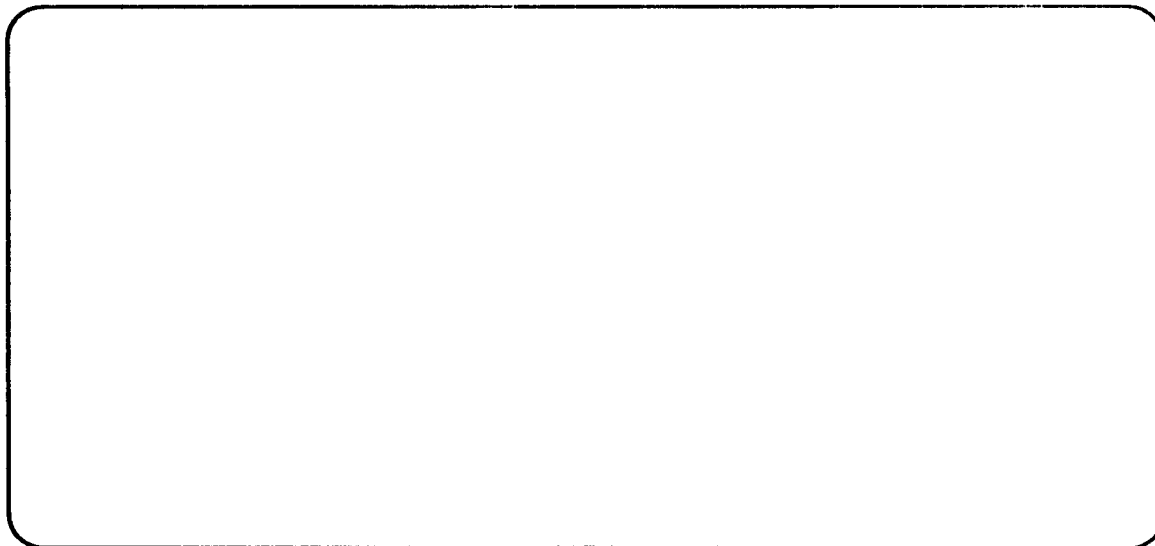
Yes ☐ No ☐

10. In view of your qualification and experience, do you consider your participation in training teachers for integrated science teaching as the most suitable job for you?

Yes ☐ No ☐

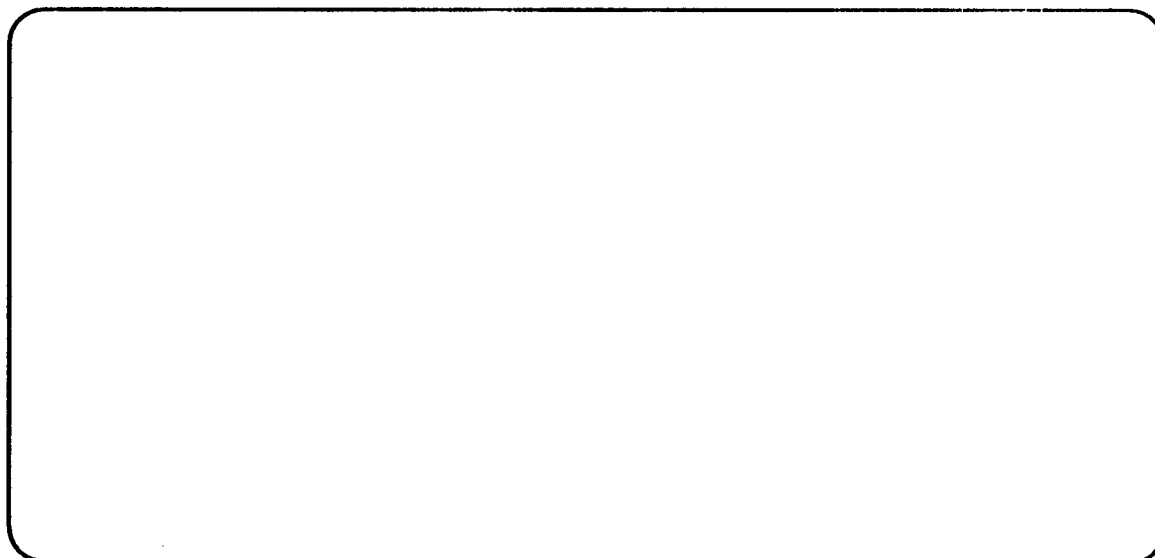
SECTION C : PERCEPTION OF INTEGRATED SCIENCE

11. Describe your understanding of integrated science

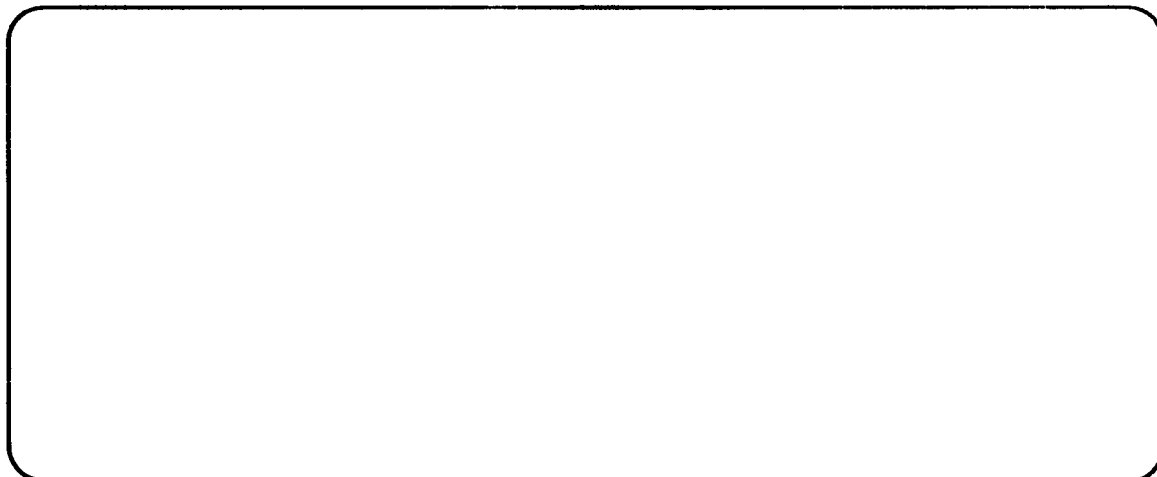


12. Do you see the training being given to the integrated science teachers in your institution as significantly different from that which the biology, chemistry or physics teachers receive? Yes ☐ No ☐

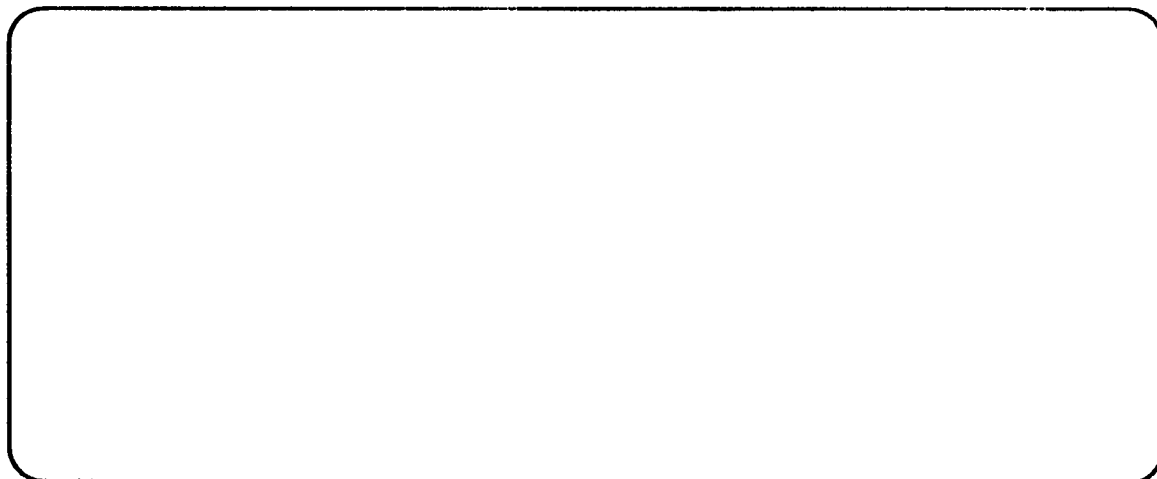
13. If your answer to question 12 above is yes, please state how they differ.



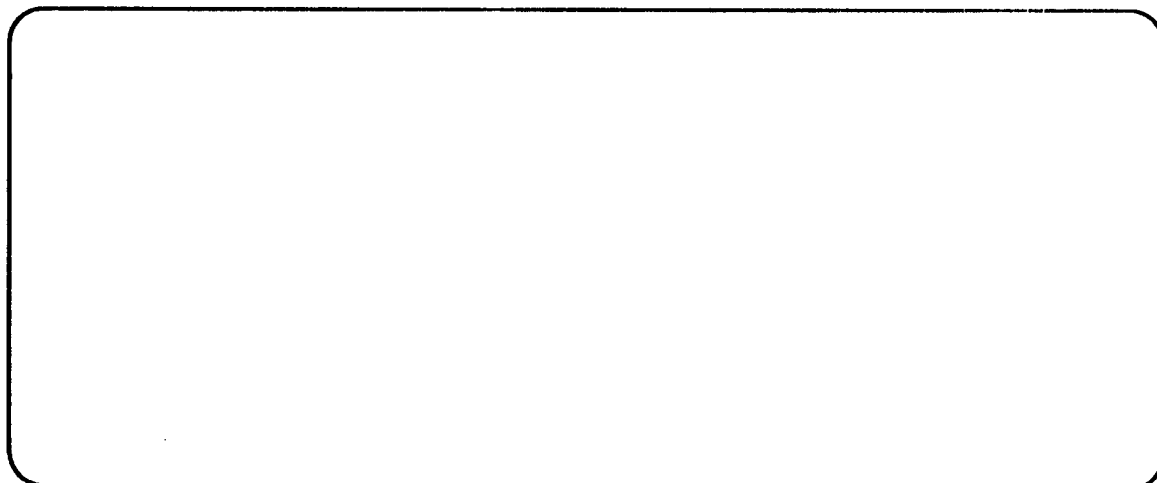
14. Please list any three(3) significant features of your training for teachers of integrated science which you consider most important in enhancing their effectiveness for the job.



15. Please list any three things you consider as weaknesses in your integrated science training programme.



16. Describe three ways in which your training programme for teachers of integrated science could be improved.



For questions 17 - 32, statements have been made, each reflecting a point of view about the meaning of integrated science and ways it can be taught in schools. Each statement is followed by a set of five responses.

Please read each statement and tick the most appropriate response to show the importance you attach to it as being an essential feature of integrated science and therefore to be included in the curriculum for integrated science teacher education. The responses are:

1. **Highly Relevant:** The statement agrees with your own view of integrated science and should therefore constitute an important element of the curriculum for the education of teachers of integrated science.
2. **Relevant:** The statement, while not in very close agreement with your own view of integrated science, does reflect to some extent relevant issues worth including in the curriculum for the education of teachers of integrated science.
3. **Neutral:** The statement neither supports nor obstructs the training of integrated science teachers. It may or may not be included in the curriculum for integrated science teacher education programme without any consequences.
4. **Unsuitable:** The statement shows no agreement with your view of integrated science and is therefore in your opinion unsuitable for inclusion in the curriculum for integrated science teacher training programme.
5. **Undecided:** The status of the statement can not be decided.

Please respond to all questions.

	Highly Relevant	Relevant	Neutral	Unsuitable	Undecided
17. The acquisition of basic knowledge in the natural sciences and the earth sciences.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18. The development of scientific attitudes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. Exploring the fundamental unity in all scientific knowledge.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20. Understanding the conceptual unity of the sciences.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. Develop competence in the unified scientific process skills.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. Exploring the relationship of science and technology.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Class discussion of social issues related to science should be considered an important type of school science lesson.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. Science courses should have strong links with environmental education.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

26. Science schemes should be developed on a suitable psychological theory of learning. ☐ ☐ ☐ ☐ ☐
27. A guided discovery approach to establishing concepts and generalizations should be used. ☐ ☐ ☐ ☐ ☐
28. Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum. ☐ ☐ ☐ ☐ ☐
29. Team teaching is an effective way of teaching integrated science. ☐ ☐ ☐ ☐ ☐
30. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of any particular contents. ☐ ☐ ☐ ☐ ☐
31. Students should be engaged in analyzing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics. ☐ ☐ ☐ ☐ ☐
32. The awareness of the limitations of science as a basis for dealing with moral and political problems. ☐ ☐ ☐ ☐ ☐

33. Please select any five (5) statements from items 17-32 above which you consider most essential in describing the meaning of integrated science in schools.

(List only the statement numbers in the boxes)

☐☐☐☐☐

34. Please list any three other issues you consider to be essential features of integrated science but have not been included in statements 17-33 above.

APPENDIX C (iii)

Integrated Science Teacher Education in Nigeria

Researcher: SUNDAY N. WUYEP

Science Department

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Director SIR PETER NEWSAM

Deputy Director PROFESSOR PETER MORTIMORE

QUESTIONNAIRE FOR INTEGRATED SCIENCE PRACTISING TEACHERS.

This questionnaire is to help me know more about your views of teaching integrated science in schools. I am interested in your views about:

1. The meaning of integration in science.
2. The adequacy of your training(if any) to teach integrated science.
3. Ways in which the training of integrated science teachers could be improved.

Please respond to all the item on the questionnaire as fully as you can You don't need to identify yourself. Thank You

SECTION A: PERSONAL DATA

1. Name of School _____

2.Address _____

3 Sex:

Male

☐

Female

☐

4. Age Group:

20 - 24

☐

40 - 44

☐

25 - 29

☐

45 - 49

☐

30 - 34

☐

50 - 54

☐

35 - 39

☐

55 & above

☐

5. What is your highest academic qualification and discipline?

Qualification _____ Subject(s) 1 _____
2 _____
3 _____

6. Which of these O'level qualifications do you possess?

WASC/GCE ☐

SSC ☐

GRADE II ☐

Others(specify) _____

7. List science subjects(s) studied at O'level.

1 _____ 4 _____
2 _____ 5 _____
3 _____ 6 _____

SECTION B: EXPERIENCES

8. How long have you been teaching integrated science? ☐ Years

9(i). During your pre-service teacher education, were you trained mainly as an integrated science teacher?

Yes ☐ No ☐

(ii). If Your answer to the above question is No, have you ever benefited from any type of course or training for teaching integrated science?

Yes ☐ No ☐

10. Which of the following reasons explains your choice of teaching integrated science?

(a) It is the subject I had my training in at the NCE level ☐

(b) I have been motivated by personal interest even though I had no prior
training for teaching integrated science ☐

(c) I was assigned to teach it for lack of trained integrated science teachers in
the school ☐

(d) Other reasons (specify) _____

11. Do you enjoy teaching integrated science?

Yes

☐

No

☐

SECTION C: INTEGRATION Vs. SEPARATE SCIENCES

12(i). Do you find integrated science more interesting to teach than separate science(s)

Yes

☐

No

☐

About same

☐

(ii). If yes, please give two reasons why you find integrated science more interesting to teach.

(iii) If No, please state two reasons for finding the separate sciences more interesting to teach than integrated science.

15. If a parent of a pupil asked you, "What is this subject 'integrated Science'?", What would you say?

Integrated science is...

SECTION D: ABOUT YOUR TRAINING AS AN INTEGRATED SCIENCE TEACHER.

(NOTE : *This section is to be responded to only by those trained as integrated science teachers)*

16. Did you undergo a Full Time ☐ or Part Time ☐ training?

17. Give reasons for your choice of full time or part time study.

18. What is your assessment of the training you received for integrated science teaching?

Good ☐ Fair ☐ Inadequate ☐

19. State below three things you found unsatisfactory about your integrated science training.

20. suggest three ways in which the training of integrated science teachers could be improved.

SECTION E: PERCEPTION OF INTEGRATED SCIENCE

Questions 21-36 contain statements which reflect points of view about the meaning of integrated science and ways it might be taught in schools. You are asked to agree or disagree with the relevance of these statements in either describing the meaning of integrated science or ways of teaching it. Please read each statement carefully and indicate your opinion by ticking the appropriate response. The responses are:

1. **Strongly Agree:** The statement expresses a point of view that matches your own view of the meaning of integrated science or its teaching.
2. **Agree:** The statement while not in close agreement with your own view of the meaning of integrated science nor its teaching, it does reflect to some extent measures of acceptable relevant issues.
3. **Undecided:** The status of the statement can not be decided.
4. **Disagree** An unimportant issue that can be ignored without making any difference to the subject matter of integrated science or its teaching.
5. **Strongly Disagree:** The statement does not match your own view of integrated science or its teaching.

Please answer all questions.

	Strongly Agree	Agree	Undecided	Disagree	strongly Disagree
21. The acquisition of basic knowledge in the basic natural sciences and the earth sciences.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. The development of scientific attitudes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Exploring the fundamental unity in all scientific knowledge.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. Understanding the conceptual unity of the sciences.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. Develop competence in the unified scientific process skills.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. Exploring the relationship of science and technology.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. Class discussion of social issues related to science should be considered an important type of school science lesson.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. Science courses should have strong links with environmental education.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30. Science schemes should be developed on a suitable psychological theory of learning.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31. A guided discovery approach to establishing concepts and generalizations should be used.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32. Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33. Team teaching is an effective way of teaching integrated science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
34. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of any particular contents.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
35. Students should be engaged in analyzing critically pieces of scientific journalism which should be considered just as much as a way of testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

understanding as having to answer a question
on such topics as osmosis, magnetism or thermodynamics.

36. The awareness of the limitations of science as ☐ ☐ ☐ ☐ ☐
a basis for dealing with moral and political problems.
-

37. Please select any five (5) statements from items 21-36 above which you consider most
essential in describing the meaning of integrated science in schools.

(List only the statement numbers in the boxes)

☐☐☐☐☐

-
38. Please list any three other issues you consider to be essential features of integrated
science but have not been included in these statements 21-36 above.

APPENDIX C (iv)

Integrated Science Teacher Education in Nigeria

Researcher: SUNDAY N. WUYEP

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Director **SIR PETER NEWSAM**

Deputy Director **PROFESSOR PETER MORTIMORE**

QUESTIONNAIRE FOR STUDENT TEACHERS

This questionnaire is to help me know more about your view of teaching integrated science in schools. I am interested in your opinions on:

1. The meaning of integration in science.
2. The adequacy of your training to teach integrated science.
3. Ways your training programme might be improved.

Please respond to all questions in the questionnaire as fully as you can. You don't need to identify yourself.

1. Name of institution _____

2. Address _____

3 Sex:

Male

☐

Female

☐

4. Age Group:

20 - 24

☐

40 - 44

☐

25 - 29

☐

45 - 49

☐

30 - 34

☐

50 - 54

☐

35 - 39

☐

55 & above

☐

5. What is your highest academic qualification and discipline?

Qualification _____ Subject(s) 1 _____

2 _____

3 _____

6. Which of these O'level qualifications do you possess?

WASC/GCE ☐

SSC ☐

GRADE II ☐

Others(specify) _____

7. List science subjects(s) studied at O'level.

1 _____ 4 _____

2 _____ 5 _____

3 _____ 6 _____

SECTION B: PRE-TRAINING EXPERIENCE

8 (i). Have you been teaching integrated science before taking up this training for integrated science teaching?

Yes ☐ No ☐

(ii). If Yes, for how long?

☐

9. At which of the following level(s) have you been involved with teaching integrated science?

(a) Primary

☐

(c) Grade II Trs. College

☐

(b) Junior Sec Sch

☐

(d) College of Education

☐

10. Which of the following reasons explains your choice of teaching integrated science?

(a) It is the subject I had my training in at the NCE level

☐

(b) I have been motivated by personal interest even though I had no prior training for teaching integrated science

☐

(c) I was assigned to teach it for lack of trained integrated science teachers in the school

☐

(d) Other reasons (specify) _____

11. Did you enjoy teaching integrated science?

Yes

☐

No

☐

SECTION C: INTEGRATION Vs. SEPARATE SCIENCES

12(i). Do you find integrated science more interesting to teach than separate science(s)

Yes

☐

No

☐

About same

☐

(ii). If yes, please give two reasons why you find integrated science more interesting to teach.

(iii) If No, please state two reasons for finding the separate sciences more interesting to teach than integrated science.

15. If a parent of a pupil asked you, "What is this subject 'integrated Science'?", What would you say?

Integrated science is...

SECTION D: ABOUT YOUR PRESENT TRAINING

16. Are you a Full Time ☐ or Part Time ☐ student?

17. Give reasons for your choice of full time or part time study.

18. What is your assessment of your present training for integrated science teaching?

Good ☐ Fair ☐ Inadequate ☐

19. State below three things you find unsatisfactory about your integrated science training.

20. suggest three ways in which your training course could be improved.

SECTION E: PERCEPTION OF INTEGRATED SCIENCE

Questions 21-36 contain statements which reflect points of view about the meaning of integrated science and ways it might be taught in schools. You are asked to agree or disagree with the relevance of these statements in either describing the meaning of integrated science or ways of teaching it. Please read each statement and indicate your opinion by ticking the appropriate response. The responses are:

1. **Strongly Agree:** The statement expresses a point of view that matches your own view of the meaning of integrated science or its teaching.
2. **Agree:** The statement while not in close agreement with your own view of the meaning of integrated science nor its teaching, it does reflect to some extent measures of acceptable relevant issues.
3. **Undecided:** The status of the statement can not be decided.
4. **Disagree** An unimportant issue that can be ignored without making any difference to the subject matter of integrated science or its teaching.
5. **Strongly Disagree:** The statement does not match your own view of integrated science or its teaching.

Please answer all questions.

	Strongly Agree	Agree	Undecided	Disagree	strongly Disagree
21. The acquisition of basic knowledge in the natural sciences and the earth sciences.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. The development of scientific attitudes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Exploring the fundamental unity in all scientific knowledge.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. Understanding the conceptual unity of the sciences.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. Develop competence in the unified scientific process skills.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. Exploring the relationship of science and technology.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. Class discussion of social issues related to science should be considered an important type of school science lesson.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. Science courses should have strong links with environmental education.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29. The selection of aims for science courses and its teaching should take into account the everyday life of the students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

30. Science schemes should be developed on a suitable psychological theory of learning. ☐ ☐ ☐ ☐ ☐
31. A guided discovery approach to establishing concepts and generalizations should be used. ☐ ☐ ☐ ☐ ☐
32. Collaboration with teachers in departments other than sciences is necessary in order to integrate science in the curriculum. ☐ ☐ ☐ ☐ ☐
33. Team teaching is an effective way of teaching integrated science. ☐ ☐ ☐ ☐ ☐
34. Work in science should be evaluated on the basis of students' ability to solve problems, not on the recall of any particular contents. ☐ ☐ ☐ ☐ ☐
35. Students should be engaged in analyzing critically pieces of scientific journalism which should be considered just as much as a way of testing understanding as having to answer a question on such topics as osmosis, magnetism or thermodynamics. ☐ ☐ ☐ ☐ ☐
36. The awareness of the limitations of science as a basis for dealing with moral and political problems. ☐ ☐ ☐ ☐ ☐

37. Please select any five (5) statements from items 21-36 above which you consider most essential in describing the meaning of integrated science in schools.

(List only the statement numbers in the boxes)

☐ ☐ ☐ ☐ ☐

38. Please list any three other issues you consider to be essential features of integrated science but have not been included in statements 21-36 above.

APPENDIX D

INTERVIEW QUESTIONS

[A] - Course Coordinators.

1. For how long have you been coordinating the integrated science teacher training in your institution?
2. What was the motivation for starting the programme in your institution?
3. What, in terms of course contents, do the student teachers go through in the course of the training and how is it being delivered?
4. What is your general assessment of your teacher training so far.
5. What would you like to see happen to improve your teacher training for integrated science?

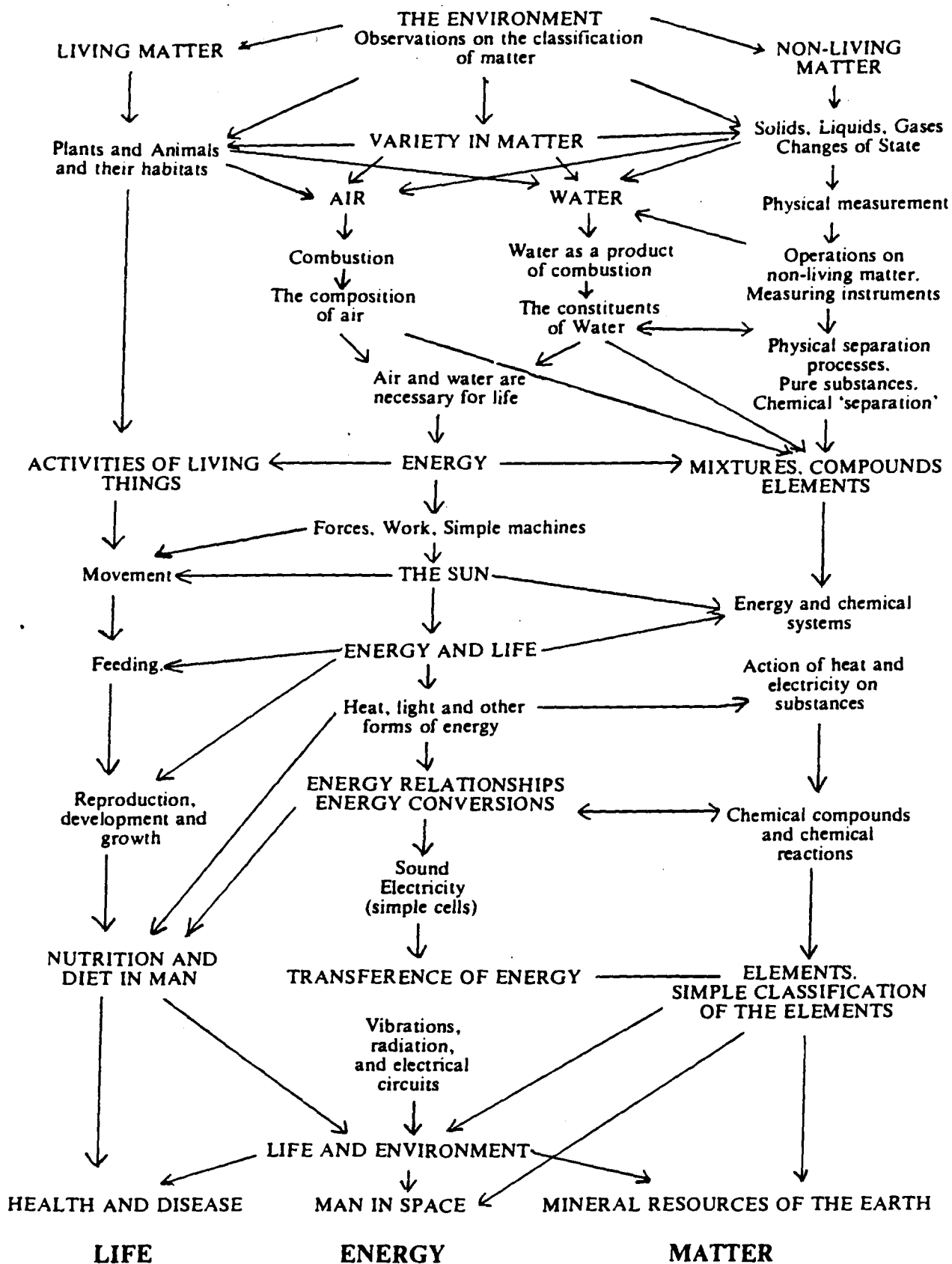
[B] - Practising Teachers.

1. For how long have been teaching integrated science in schools?
2. Is your qualification in integrated science?
3. What do you think of integrated science and its teaching in schools?
4. Have you found your training for integrated science teaching very helpful?
5. What do you suggest towards improving your teaching and the learning of integrated science by your pupils?
6. What practical things would you want to see incorporated into the teacher training curricula for integrated science?

[C] -Student Teachers.

1. Have you ever taught integrated science before entering this training for integrated science teaching?
2. What was your motivation for taking up this training for integrated science teaching?
3. What is your general assessment of your training (weaknesses and strengths)?
4. You would have gone on some teaching practice exercises (once or twice) during your course, what was your experience?
5. How would you like to see your training improved?

APPENDIX E



A FLOW CHART OF THE OUTLINE CONTENT OF STAN INTEGRATED SCIENCE

APPENDIX F (i)

INTEGRATION CHECKLIST FOR THE NIGERIAN INTEGRATED SCIENCE CORE CURRICULUM FOR THE JUNIOR SECONDARY SCHOOL (12-14Yrs)

THEMES	TOPICS	As unity of all knowledge (form part of covering theme).	As conceptual unity (conceptual schemes/major concepts).										As unified process of enquiry.								As social relevance (by mention/applicat ion/implication).	As Interdisciplinary (scope/number of disciplines drawn upon).
			DIVERSITY	CHANGE	CONTINUITY	INTERACTION	SYSTEM/ORGANISATION	CYCLES	ENERGY	FORCES	OBSERVING	CLASSIFYING	REPORTING	ORGANIZING	GENERALIZING	PREDICTING	EXPERIMENTING	USING/MAKING MODELS	MEASURING	PROBLEM SOLVING		
1.	1	✓	✓								✓	✓	✓		✓							Bio.
	2	✓	✓								✓	✓	✓	✓	✓					✓		Bio.
	3	✓					✓											✓		✓		Bio
	4	✓					✓				✓							✓				Bio
	5	✓									✓	✓	✓	✓	✓	✓					✓	Bio, H/sc.
	6	✓					✓				✓		✓	✓	✓	✓	✓	✓		✓		Bio
	7	✓		✓							✓		✓				✓			✓		Bio., Chem.
	8	✓									✓						✓	✓		✓		Bio
	9	✓		✓	✓		✓	✓			✓							✓			✓	Bio
	10	✓																		✓		H/science
2	1	✓	✓								✓		✓	✓			✓			✓		Bio, H/Science
	2	✓									✓	✓	✓	✓	✓		✓				✓	Bio, Agric.Sc., H/Science.
	3	✓							✓												✓	Bio, Chem, Phy, Tech. Sc.
	4	✓			✓						✓		✓	✓	✓	✓					✓	Bio, H/Science
	5	✓																		✓	✓	Bio, H/Science

	6	✓																✓	✓	Phy, Tech. Sc.
3	1	✓	✓																	Bio
	2	✓	✓																	Bio
	3	✓	✓															✓		Bio
	4	✓	✓															✓		Bio, Earth Sc., Chem
	5	✓	✓															✓		Bio, Agric. Sc., Chem.
4	1	✓	✓																	Bio
	2	✓	✓																	Chem, Bio, Phy, Skill
	3																			Phy, Chem*
	4	✓	✓																	Chem, Phy, Earth/Sc.
	5	✓	✓															✓		Chem, Phy
	6	✓	✓															✓		Chem
	7																	✓		Earth/Sc.
	8	✓	✓																	Chem, Phy
	9	✓	✓															✓		Chem
	10	✓	✓																	Chem
	11	✓	✓																	Chem
	12	✓	✓															✓		Chem
	13																			Phy
	14																			Skill
	15	✓	✓																	Chem
	16	✓	✓																	Chem.
	17	✓	✓																	Chem
	18	✓	✓																	Chem
	19	✓	✓															✓		Chem
	20	✓	✓															✓		Phy., Chem

		21	✓														✓		Phy, Tech. Sc
		22	✓																Chem
		23	✓														✓		Phy, Earth Sc.
5		1	✓														✓		Tech. Sc.
		2	✓														✓		Tech. Sc.
		3	✓														✓		Phy
		4	✓														✓		Phy
		5	✓														✓		Phy, Tech. Sc.
		6	✓														✓		Phy, Tech. Sc.
		7	✓														✓		Phy, Tech. Sc.
6		1	✓														✓		Bio, H/Sc., Tech. Sc.
		2	✓														✓		Bio, H/Sc.
		3	✓														✓		Bio, H/Sc.
		4	✓														✓		Bio, H/Sc.
		5	✓														✓		Bio
		6	✓														✓		Bio, Earth Sc., Chem.
		7	✓														✓		Earth Sc, Bio, Ag/Sc.
		8	✓														✓		Earth Sc.
		TOTAL																	

APPENDIX F (ii)

INTEGRATION CHECKLIST FOR THE NIGERIAN INTEGRATED SCIENCE TEACHER EDUCATION PROJECT (NISTEP) - NCE LEVEL

THEMES	TOPICS	As unity of all knowledge (form part of covering theme),	As conceptual unity (conceptual schemes/major concepts),								As unified process of enquiry.								As social relevance (by mention/applcation/implication),	As interdisciplinary (scope/number of disciplines drawn upon).		
			DIVERSITY	CHANGE	CONTINUITY	INTERACTION	SYSTEM/ORGANISATION	CYCLES	ENERGY	FORCES	OBSERVING	CLASSIFYING	REPORTING	ORGANIZING	GENERALIZING	PREDICTING	EXPERIMENTING	USING/MAKING MODELS	MEASURING	PROBLEM SOLVING		
1	1	✓																			✓	Maths
	2	✓																			✓	Maths
	3	✓																			✓	Maths
	4	✓																			✓	Maths
	5	✓																			✓	Maths
	6	✓																			✓	Maths
	7	✓																			✓	Maths
	8	✓																			✓	Maths
2	1	✓									✓										✓	Bio / Science skill
	2	✓																	✓		✓	Science
	3	✓										✓									✓	Science, Bio
	4	✓																		✓	✓	Science, Tech
3	1	✓																			✓	Chem, Bio
	2	✓		✓				✓													✓	Chem, Earth/sc, H/sc
	3	✓									✓		✓								✓	Earth/sc

	4	✓							✓									✓	Earth/sc, Agric
	5	✓								✓								✓	Bio
	6	✓									✓							✓	Bio
	7	✓																	Bio
	8	✓							✓									✓	Bio
	9	✓																✓	Bio
4	1	✓						✓									✓	✓	Phy, Chem, Bio
	2	✓						✓									✓	✓	Chem, Phy, Bio
	3	✓						✓									✓		Phy
	4	✓						✓									✓		Phy
	5	✓						✓									✓		Phy, Bio
	6	✓						✓									✓		Phy, Bio
	7	✓							✓										Phy
	8	✓							✓										Phy
	9	✓						✓									✓		Phy, Chem, Earth/sc
	10	✓						✓									✓		Phy
	11	✓						✓									✓		Phy
5	1	✓															✓		Chem
	2	✓							✓								✓		Chem
	3	✓								✓									Chem
	4	✓						✓											Chem
	5	✓							✓								✓		Chem
6	1	✓						✓									✓		Bio
	2	✓						✓									✓		Bio, Chem
	3	✓							✓										Bio
	4	✓							✓								✓		Bio

	5	✓																✓	Tech
	6	✓																✓	Tech
18	1	✓																✓	Bio
	2	✓																✓	Bio
	3	✓																✓	Earth/sc, H/sc
	4	✓																✓	H/sc, Tech
19	1	✓																✓	Science, Tech
20	1	✓																	Chem
	2	✓																	Chem, Bio
	3	✓																✓	Chem, Bio
	4	✓																	Chem
	5	✓																	Chem
	6	✓																	Chem
21	1	✓																✓	Phy
	2	✓																✓	Phy
	3	✓																✓	Phy

APPENDIX G

INTEGRATED SCIENCE CORE-CURRICULUM FOR JUNIOR SECONDARY SCHOOLS IN NIGERIA.

1. THEME: YOU AS A LIVING THING.

TOPIC	PERFORMANCE OBJECTIVES	CONTENTS	ACTIVITIES
YEAR 1 1. Characteristics of living things	The child should be: 1. identify those characteristics that separate living things from non-living things. 2. use such criteria to sort objects into living and non-living things. 3. identify self as a living thing. 4. use these criteria to identify others as living things.	1. Characteristics shown by all living things. 2. Discovery and identification of things in the school compound. 3. Identifying self as a living thing.	Perform and observe some activities of living things. Discussion to lead to identifying the characteristics of living things. 2. A brief look around the school compound to make collections. Classify the collections made into living and non living things. 3. Class discussion on how each qualifies to be called a living thing. Do they each show all the characteristics?
2. Characteristics of animals and plants.	The child should be: 1. differentiate between plants and animals. 2. use simple microscope. 3. make good drawing records of observations.	1. Structure of plant and animal cells. Comparison of both. 2. Characteristics in activities of cell structure and food production which differentiate plants from animals.	1. Observe simple cells and see their cell contents. 2. Make simple drawing of cells. 3. The child should contrast the movement behaviour of plants and animals. Animals can move totally from place to place. 4. Match the characteristics of animals to yours. Are you an animal? 5. Demonstrate how plants can photosynthesize and deduce that animals cannot.
3. Human beings as intelligent animals.	The child should be able to show that human beings are intelligent animals.	1. Human intelligence, shown by his organizational and problem solving skills, etc. 2. Examination of his hand - designed to use tools.	1. Discuss man's intelligence. 2. Examine the hands or a model skeleton of hands of man and some other animals. Let the child examine and see how his thumbs are opposed to the forefingers and how the hand is adapted to handle tools.
4. Know your body.	The child should be able to identify the: 1. main parts of the body. 2. main systems of the body.	1. Identification of head, neck, trunk, limbs etc. 2. Identification of systems of the body from charts e.g. digestive, respiratory, circulatory, excretory, etc.	1. Draw and label the parts of the body. 2. Use charts to identify systems and how they are related to major organs and to each other.

5. Feeding.	The child should be able to: 1. identify food items and their sources. 2. identify the functions of food to human beings; 3. observe human teeth; 4. take care to his/her teeth.	1. Food items and their sources. 2. Groupings of foods. 3. Discussing and grouping them by their scientific names. 4. Teeth and their care.	1. Let pupils make lists of familiar food items. Where do we get them from? 2. Classify them in many ways. Each grouping must be justified by pupils, e.g. by sources; whether eaten raw or cooked; local or foreign, solid or liquid, etc. 3. Classify foods in terms of their uses to the body: Carbohydrates, proteins, etc. and let pupils re-classify their list. 4. Let each child count his/ her teeth and observe their shape. Introduce the names incisor, canine, premolar, molar, and the dental formula. 5. Guide the child in teeth care: cleaning, good diet and visits to the dentist, etc.
YEAR 2 Movement: Skeleton, Muscles and joints	The child should be able to: 1. identify main bones of the body. 2. observe how they are put together to function. 3. discover how muscles together with bones make movement possible. 4. discover the components of a joint 5. identify the mechanics of movement.	1. Main bones of the Skeletal system. 2. Major function of the skeletal system. 3. Muscles , joints and movement. 4. Body movement as machine.	1. Allow pupils to feel and count bone of parts of the body - arm, head, legs, fingers, etc. and record. 2. Discuss function of skeletal system and let the child illustrate using his body - Support, Protection and Movement. 3. Identify major joints - at wrist, the elbow, ankle, knee, shoulder etc. In how many ways can a joint be moved? N.B. Introduce concept of simple machines. 4. Compare the elbow joint and knee joints. Let children feel the muscles involved and discover the antagonistic muscles as one relaxes the other contracts (biceps and triceps of the upper arm). 5. Find out the mechanics of the feet as man walks and compare to a lever.
Excretory System.	The child should be able to: 1. define an excretory waste. 2. identify excretory organs, 3. discover how the organs work. 4. recognise the need to excrete.	1. Excretion and need for it. 2. Excretory organs and their functions. 3. Excretory products.	1. Lead a discussion on different types of : (a) excretory wastes and (b) nature of these wastes. 2. Using and charts, explain the action of kidney; the skin and the sweat glands, and the lungs as excretory organs. 3. Explain using models and charts, the structure and action of the kidney, the skin and the lungs as excretory organs. N.B. that the lung has relatively large surface area.

Respiratory System.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. discover that respiration is more than breathing. 2. identify parts involved in breathing and observe breathing mechanisms; 3. identify breathing problems; 4. recognise that breathing varies with changes in external pressures. 	<ol style="list-style-type: none"> 1. Respiration as release of energy (Human beings :use air in respiration), 2. Mechanism and part involved in breathing. 3. Breathing and outside pressure: high altitude, deep in the sea. 4. Problems connected with breathing e.g. asthma. 	<ol style="list-style-type: none"> 1. Test for heat release when breathing out. 2. Test product of respiration for carbon dioxide and water. 3. Feel parts of the body involved in breathing. 4. Demonstrate a simple experiment to show pressure and volume principles in breathing. 5. Discuss how patients of asthma find breathing difficult. How are they to be aided?
Circulatory System.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. recognise components of blood; 2. recognise the function of blood; 3. recognise how the organs work and relate to other systems; 4. be aware of blood diseases. 	<ol style="list-style-type: none"> 1. Component of blood and functions. 2. Blood vessels. 3. The heart, simple structure and functioning. 4. Blood defects or diseases. 	<ol style="list-style-type: none"> 1. Examine a blood smear; note corpuscles. Examine a good chart of the vessels, paying attention to the major vessels. How they are connected to the heart. 2. Discuss the transport and defence functions. 3. Use the models and charts to study the human heart structure. 4. Discuss sickle cell anaemia and malaria parasite in blood corpuscles.
Digestive System.	<p>The child should :</p> <ol style="list-style-type: none"> 1. be able to identify parts of the alimentary system and the role play in digestion. 2. recognise that foods are chemicals. 3. be able to describe digestion and absorption. 	<ol style="list-style-type: none"> 1. Parts of the digestive system, from mouth to anus. 2. Simple food tests. 3. Digestion at various points. 4. Absorption of food. 	<ol style="list-style-type: none"> 1. Use charts, models or preserved specimens to study the alimentary system stage by stage, A visit to a butcher to observe the alimentary system of a cow and compare it with the human system aids learning. Discussion and illustration. 2. Perform food tests and observe changes only. 3. With the aids of charts, discuss digestive processes of the various food types, their absorption and the elimination of the undigested and indigestible part of food(faeces).
YEAR 3 Food storage.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. recognise that the breakdown of food is both a physical change and an enzyme action (chemical change). 2. recognise what happens to absorbed food; 3. recognise the fate of excess food. 	<ol style="list-style-type: none"> 1. Action of enzymes in food. 2. What happens to absorbed food? Carbohydrate in excess is stored as glycogen , fats are stored as body fat. Excess protein is destroyed by the liver. 	<ol style="list-style-type: none"> 1. Let the children chew non-sweetened bread in their mouth for a while. What happens? 2. Discuss where glycogen is stored: so also fats and oils. Which of these may be used by the body again? N.B. Excess protein is harmful, it over works the liver to produce urea and uric acid which are excreted.

Nervous System and Sense organs.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. trace how a stimulus is received and responded to; 2. identify the sense organs; 3. observe the functioning of the organs; 4. examine defects in the organs. 	<p>1. The CNS (Central Nervous System) as centre of sensitivity, brain , spinal cord stimuli go via nerves. Simple reflex action and examples.</p> <ol style="list-style-type: none"> 2. Sense organs: eye, ear, nose, tongue and skin. 3. Types of eye defects and their correction with glasses/lenses. 	<ol style="list-style-type: none"> 1. Use charts to trace pathways of nervous messages. Examine and relate this to say a touch on a hot iron. 2. Treat each sense organ simply: <ol style="list-style-type: none"> (a) Tongue - taste various things to locate spots of sensitivity on tongue; (b) Eye - How far/near can you read? Colour blindness. (c) Ear - How good is your hearing? 3. Discuss principles by which glasses correct short and long sightedness.
Reproductive System	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. develop the definition of reproduction; 2. identify the main parts of the reproductive system; 3. know that reproduction preserves species; 4. develop simple human reproductive cycle; 5. recognise secondary (biological/body) sexual changes. 	<ol style="list-style-type: none"> 1. Definition of reproduction. 2. Main parts of the reproductive system. 3. Reproduction and family tree. 4. The human reproduction cycle. 5. Changes that accompany puberty in boys and girls. 	<ol style="list-style-type: none"> 1. With the aid of charts, lead a discussion to impress on the child that reproduction is 'giving rise to the young after one's kind'. 2. Use a chart, model, or specimen to identify main parts of the reproductive system. 3 Let children develop a summary of reproduction in a cycle form. 4. Let children develop simple family tree of their respective families. (This is possible because there has been reproduction). 5. Careful discussions (led by teacher) on changes noticeable at puberty.
Health.	<p>The child should:</p> <ol style="list-style-type: none"> 1. know the causes of common ill health; 2. know and observe simple rules of keeping fit. 	<ol style="list-style-type: none"> 1. Health and its maintenance. 2. Need of health in growth. 3. Keeping fit through good exercise, good diet, good hygiene. 4. Drug abuse. 	<ol style="list-style-type: none"> 1. Let children mention/describe common diseases. Help them discover the causes and what can be done about them. 2. Let them examine how ill health may retard growth physically and mentally. 3. Role of exercise and good food. Let them undertake various projects on hygiene of home and school compound. Let the result be tabulate and discussed.

2. THEME: YOU AND YOUR HOME.

<p>YEAR 1 Health of the Family.</p>	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. list habits that promote personal cleanliness and state the dangers of not keeping these habits. 2. identify characteristics of polluted water; 3. state the dangers of drinking polluted water; 4. state how to purify water from wells or streams; 5. list causes of polluted air in the home and its surroundings; 6. describe ways by which garbage collection and disposal can be improved. 7. state the value of a good sewage system to health; 8. identify symptoms of asphyxia. 	<ol style="list-style-type: none"> 1. Improving personal cleanliness by regular brushing of teeth, regular bathing, washing of hair and regular laundry of cloth, cutting of nails, etc. 2. Polluted Water in the home: <ol style="list-style-type: none"> (a) identification of polluted water by colour , odour, clarity, etc. (b) awareness of health hazards in drinking and using dirty and polluted water; advantages of pipe-borne water; (c) purification of water obtained from wells or streams, by boiling, filtering, and adding chemical e.g. chlorine. 3. Polluted air in the home: <ol style="list-style-type: none"> (a) Causes: Poor ventilation, over-crowding in the bedroom, burning of coal, mosquito coil, incense in the room, foul germ-carrying air from dirty kitchen, toilets and surroundings. (b) Awareness of danger of polluted air in the home e.g. asphyxia. (c) Prevention of polluted air e.g. adequate ventilation in the room, avoidance of burning of coal, mosquito coil, and incense in crowded rooms, also regular dusting. 4. Dirty Environment around the home: <ol style="list-style-type: none"> (a) identification of dirty environment e.g. littering of refuse, poor sewage, lack of or poor maintenance of toilets. (b) prevention against having dirty environment, by regular sweepings of home and surroundings, regular cleaning of gutters, and dumping of garbages in provided bins and areas. 	<ol style="list-style-type: none"> 1. The pupil list habits that promote personal cleanliness and point out how to improve on them. 2. Collect water from pond, well, gutter, stream and running tap. 3. Identify, experimentally, the similarities and differences in colour, odour, precipitation, acidity etc. of the water collected. 4. Purify water by boiling, filtering or adding chemicals (e.g. Milton).
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YEAR 2 Growth and Development.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. name things that affect child's growth and development, 2. classify foods that are common in their locality; 3. state nutrients found in different food types; 4. state the composition of a balanced diet for breakfast, lunch and dinner; 5. clean a suitable site near their home and sow viable seeds; 6. care for the growing plants by weeding, manuring and applying fertilizers, watering and removing pests; 7. harvest the product. 	<p>1. Factors that affect growth and development:</p> <p>(a) Food - types of food including breast milk nutrients in different types of food; Vitamins - balanced diet: composition and frequency of balanced diet - sources of food including home gardening, poultry etc. to supplement other resources of food for the home.</p> <p>(b) Diseases.</p> <p>(c) Hereditary factors.</p> <p>2. Cultivation and harvesting of crops.</p>	<p>1. Collect different foodstuff from the local market.</p> <p>2. Classify them and find out the nutrients that each contains by performing food tests.</p> <p>3. Pupils sow viable seeds in the school garden or near their home.</p>
Energy and Appliances in the Home - Forms of Energy.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. list uses of energy in the home; 2. name sources of that energy; 3. recognise various forms of energy. 	<p>1. Use of energy in the home e.g. walking, doing house hold work and playing, cooking seeing, operating appliances.</p> <p>2. Energy sources:</p> <p>(a) natural sources e.g. food sun, wood, coal, natural gas, oils and fats.</p> <p>(b) manufactured sources e.g. batteries, generators and electricity from the mains.</p> <p>(c) petroleum product e.g. kerosene.</p> <p>3. Forms of energy: Heat, Electrical, Light, etc.</p>	<p>1. Demonstrate the use of various energy appliances in the students environment .</p> <p>2. Lead a discussion in the various available energy sources in Nigeria.</p> <p>3. simply the concepts of heat, electrical, light energy, light energy etc.</p>
YEAR 3 Continuity of the family.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. name members of their nuclear and extended family; 2. prepare a family tree from the information in (1); 3. identify physical resemblances and differences amongst members of the family. 4. recognise dominant traits in the family; 5. show the trend of appearances of dominant traits in the family tree (3 generations). 	<p>1. Identification of members of the nuclear family and extended family.</p> <p>2. Identification of physical resemblances and differences in the nuclear and extended family e.g. 6th finger, height, baldness, fairness etc.</p> <p>3 Identification of dominant/recessive traits of these resemblances as they appear/disappear in 3 successive generations.</p>	<p>Draw heavily on the experience of the pupils on this topic. Instruct them to collect information for performance objectives (1) and (3). During classroom discussion, explain the meaning of dominant and recessive traits, illustrating with examples brought from home. Point out trends in a particular family tree.</p>

Care of the Child	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. name diseases that are common in children in Nigeria and state how to prevent them; 2. list the symptoms of these diseases; 3. state the diseases against which they have been immunized; 4. state the importance of good child rearing and socialization. 	<p>1. Medical Care:</p> <ol style="list-style-type: none"> (a) importance of immunization and prevention against diseases like measles, smallpox, polio, tuberculosis, whooping cough, yellow fever, cholera, malaria; (b) regular reading according to doctor's or midwife's directives; (c) awareness that each child is an individual with unique physical, mental and psychomotor skills. <p>2. Socialization of the child- the direct responsibility of the parents in:</p> <ol style="list-style-type: none"> (a) discipline, (b) learning of cultural norms. 	<p>1. A guided tour/visit of a local hospital essential to provide knowledge or local diseases and child birth.</p> <ol style="list-style-type: none"> 2. Finding out and insuring that the child has been immunized against diseases mentioned above. 3. Lead discussion on child rearing and socialisation.
Energy and Appliances in the home.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. name the appliances in the home and discuss how they function; 2. recognise that energy is converted from one form to another in the home; 3. suggest possible faults in an electrical appliance that fails to function.. 	<p>1. Appliances in the home (differentiation of traditional and modern appliances).</p> <p>2. Conversion of Energy in the home:</p> <ol style="list-style-type: none"> (a) chemical energy to heat and light (burning fire wood, or candle); (b) electrical energy to heat, light, sound, mechanical energy e.g. electric iron, T.V. radio, telephone, electric bell, grinder, fans. 	<p>1. Pupils bring some electrical appliances to school with minor faults and are guided in identifying at least 4 possible faults in each.</p> <p>N.B. The teacher should take and teach, safety precautions during this activity.</p> <p>2. Demonstrate conversion of energy.</p>

3. THEME: LIVING COMPONENTS OF THE ENVIRONMENT.

YEAR 1 Classification of matter.	The child should be able to: 1. identify a living thing; 2. identify a non-living thing; 3. sort out different examples of matter into living matter and non-living matter.	1. Characteristics of living things; cellular composition, locomotion, feeding, excretion, respiration, irritability, growth, reproduction. 2. Classification of matter into living matter and non-living thing matter	Examine cells from: (a) epithelial living from inside of human cheek; (b) epidermis of swollen leaf of onion bulb or water-leaf; 2. Collect different types of matter from the environment. 3. Sort common examples of matter into living matter and non-living matter. 4. Observe characteristics of living things among matter found in water, on land, and the air.
Groups of organisms.	1. classify organisms into plants or animals; 2. identify an organism as either a plant or an animal; 3. describe the distinguishing characteristics of plants and animals; 4. observe diversity among organisms; e.g. flowering and non-flowering plants.	1. Comparison of plants and animals using the characteristics of living things.	1. Compare a flowering plant in the neighbourhood with an enclosed but living animal using the characteristics of living things. 2. Examine and compare a plant cell with an animal cell. 3. Examine a collection of organisms assembled to show variety among organisms. 4. Classify plants into flowering and non-flowering. 5. Classify animals into vertebrates and non-vertebrates. 6. Classify vertebrates into the following groups: fishes, reptiles, amphibians, birds, mammals.
Activities of Living Things: (a) Locomotion and Movement.	The child should be able to: 1. state the purposes served by movements in living things; 2. distinguish between types of movement; 3. describe the methods of locomotion on land, in water and in air; 4. identify locomotory organs; 5. relate methods of locomotion to structure of locomotory organs; 6 illustrate passive movements among living things; 7. list the effects of movement on population.	1. Types of movement. 2. Methods of locomotion: crawling, wriggling, walking, jumping, running, swimming; 3. Different locomotory organs. 4. Passive movements - floating, drifting, gliding, carrying.	1. Observe animals illustrating different methods of locomotion. 2. Watch slow-motion film illustrating different methods of locomotion.

(b) Feeding.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. state the functions of food to organisms; 2. describe the different modes of feeding; 3. relate feeding habit among animals to dentition; 4. classify organisms according to their modes of feeding. <p>The child should be able to:</p> <ol style="list-style-type: none"> 1. state the need for excretion; 2. list different kinds of waste products; 3. list different excretory organs. <p>The child should be able to:</p> <ol style="list-style-type: none"> 1. state the function of respiration; 2. list different respiratory organs. <p>The child should be able to:</p> <ol style="list-style-type: none"> 1. state the need for sensitivity by organisms; 2. list sense organs for perceiving the stimuli of touch, light, sound, and chemicals. 	<ol style="list-style-type: none"> 1. Functions of food. 2. Autotrophism and Heterotrophism. 3. Herbivores, Carnivores and Omnivores. <ol style="list-style-type: none"> 1. Need for excretion. 2. Waste products. 3. Organs responsible for excretion. <ol style="list-style-type: none"> 1. Need for respiration. 2. Organs responsible for respiration. 1. Need for irritability. 2. Sense organs. 3. Response shown by some organisms to external stimuli: taxis, tropisms. <ol style="list-style-type: none"> 1. Factors which influence growth. 2. Germination of seeds. <ol style="list-style-type: none"> 1. Types of reproduction. 2. Fertilization. 3. Life history of mosquito or housefly, and flowering plant. 	<ol style="list-style-type: none"> 1. Examine jaws of carnivores, herbivores and omnivores dentition. 2. Relate the dentition to the mode of feeding. <ol style="list-style-type: none"> 1. Use Charcoal iron to demonstrate need for eliminating waste. 2. Examine the kidney, skin and leaf as excretory organs. <p>Examine lungs, gills and stomata.</p> <ol style="list-style-type: none"> 1. Carry out simple experiments to illustrate tropisms and taxis. 2. Carry out simple experiments to perceive the stimuli of touch, light, sound and chemicals. <ol style="list-style-type: none"> 1. Carry out experiments to investigate conditions necessary for the germination of seeds, 2. Carry out experiments to demonstrate growth and growth patterns in animals and plants. <ol style="list-style-type: none"> 1. Observe the life history of mosquito or housefly, and a flowering plant. 2. Observe vegetative reproduction in plants.
(c) Excretion.			
(d) Respiration.			
(e) Irritability.			
(f) Growth and Development.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. define growth; 2. state the factors which influence growth and development; 3. describe the sigmoid pattern of growth. <p>The child should be able to:</p> <ol style="list-style-type: none"> 1. state the need for reproduction; 2. distinguish sexual reproduction from asexual reproduction. 3. describe the life history of mosquito or housefly, and a flowering plant. 		
(g) Reproduction			

YEAR 2 Ecology	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. list the biotic and abiotic factors of the environment; 2. state that green plants can convert radiant energy (from the sun) to chemical energy (in form of food); 3. state that animals derive their energy from plants; 4. define population and community; 5. recognise the inter-dependence among living things; 6. recognise the need for maintaining balance in nature. 	<ol style="list-style-type: none"> 1. Biotic and Abiotic factors of the environment. 2. Transfer of energy from the non living to the living world by green plants. 3. Food chains and food webs; Trophic levels. 4. Population and Population density. 5. Community. 6. Interaction among living things and between living and non living things. 7. Water cycle, carbon cycle, and nitrogen cycle. 	<ol style="list-style-type: none"> 1. Test for starch. 2. Test for starch in a leaf. 3. Demonstrate that sunlight is necessary for photosynthesis. 4. Shoe by experiment that chlorophyll is necessary for photosynthesis. 5. Observe feeding relations from the environment. 6. Determine population density of plants by the quadrat method.. 7. Conduct specific habitat studies including terrestrial and aquatic habitats e.g. a playing field, a pond, a stream or a tree. 8. Perform simple experiments on condensation of water vapour to demonstrate water cycle. 9. Observe the interaction in the environment e.g. grasshopper on grass, rat on fruits.
YEAR 3. Resources from Living Components of the Environment.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. list examples of food crops and cash crops, and farm products; 2. acquire knowledge about economic importance of selected examples of food crops and cash crops; 3. state the value of the livestock enterprise; 4. describe the processing of hides and skin; 5. recognise the uses of hides and skin; 6. define a beast of burden; 7. list examples of beast of burden. 8. state the uses of selected examples of beast of burden; 9. list examples of timber; 10. list uses of timber; 11. recognise the presence of dyes in parts of selected plants; 12. recognise the medicinal value of some plants; 13. state the industrial uses of yeast; 14. describe the process of fermentation; 15. describe the process of making manure; 16. specify the value of manure. 	<ol style="list-style-type: none"> 1. Common food and cash crops of Nigeria and their importance. 2. Livestock. 3. Fishery. 4. dairy Products. 5. Hides and skin and processing. 6. Beast of burden. 7. Timber. 8. Chemicals: <ul style="list-style-type: none"> - Dyes, - Drugs, - Yeast. 9. Yeast. 10. Manure. 	<ol style="list-style-type: none"> 1. Collect samples such as cassava, yam rice, corn, oil palm, rubber, cocoa, groundnut etc. 2. Children write on economic importance of each. 3. Visit to relevant places of interest; observe and gather data on dairy products, poultry, fishery and any other in the locality. 4. Watch films from Ministry of agriculture showing processing of hides and skin. 5. Make drawings of various animals used e.g. Horse, Camel, Donkey, Oxen etc. and identify their location and economic importance. 6. Visit a saw mill, collect pieces of timber and list uses; availability etc. 7. Extract dyes from flowers, leaves and bark. 8. Collect medicinal plants from the locality and write about their uses. Teacher demonstrate fermentation with yeast and sugar in water.

4. THEME: NON-LIVING COMPONENTS OF THE ENVIRONMENT.

YEAR 1. Observing samples of non-living things.	The child should be able to: 1. use his/her senses of feeling and touching, hearing, smelling and tasting accurately while observing things around; 2. develop skill in detailed observations of things; 3. record accurately his/her observation; 4. appreciate the limitation of using his/her senses.	1. Observing samples of non-living things. 2. Limitation of our senses. 3. Use of devices to aid our senses.	1. Collect different types of matter. 2. Observe them using our different senses.
Classification of Non-living components.	The child should be able to: 1. choose reasonable criteria for classifying given objects; 2. identify what objects are solids, liquids and gases; 3. identify the differences in grouping on the basis of criteria.	1. Criteria for classification - colour, smell, size shape, texture, taste, etc. 2. Classifying into solids, liquids and gases.	1. Classify objects to groups according to criteria of colour, smell, texture, taste, shape etc. Group objects into solid, liquid and gas.
Measurement	The child should be able to: 1. understand the need for a standard of measurement; 2. demonstrate knowledge of the S.I. Units for length, mass, time; 3. use simple measuring devices to measure some given quantities; 4. construct some simple measuring devices.	1. Need for a standard of measurement. 2. Measuring devices - metre rule, a balance, a clock, a thermometer cylinder. 3. Measurement of length, mass, time, temperature and of volume.	1. Measure with e.g. foot, span, pace, cubit etc. and establish the need for a standard of measurement. 2. Measure with metre rule, balance, clock, thermometer, measuring cylinder, etc. N.B.: Teacher should ensure, at this early stage that the children are familiar with the scale readings of the measuring instruments and measurements should be recorded correct to the minimum scale division. 3. Construct simple measuring devices e.g. shadow clock, candle pan balance, spring balance.

State of Matter	The child should be able to: 1. identify the three states of matter; 2. recognise that matter is made up of discrete particles which are in a state of motion; 3. acquire a knowledge of a model of the states of matter built on the particulate theory; 4. use the particulate theory to explain a number of commonly observable phenomena.	1. Solids, liquids and gases - water as an example. 2. Particulate theory of matter. 3. Use the particulate theory of matter to explain evaporation, boiling, melting, compressibility, pressure, cloud formation, water cycle, expansion.	1. Observe gradual changes of state of water. 2. Observe gradual spread of potassium permanganate in water. 3. Perceive the smell of concentrated aqueous ammonia. 4. Mix equal column of two different mixable liquids and explain the nature of a mixture. 5. Perceive the smell of solid naphthalene (camphor).
Air	The child should be able to: 1. recognise that air is in our environment; 2. identify the main constituents of air; 3. state some properties of air.	Pressure of air in our environment. 2. Composition of air. 3. Properties of air - has weight, exerts pressure, is compressible, is a mixture, moves (i.e. wind)	1. Observe air in motion. 2. Fly a kite or a balloon. 3. Leave a glass of water overnight (observe bubbles). 4. Burn a candle in a given volume of air to show that air is made up of two major parts. 5. Weigh a given volume of air. 6. Demonstrate that air exerts pressure using partially evacuated can. 7. Use a bicycle pump to compress air. 8. Demonstrate air in soil.
water	The child should be able to: 1. identify various sources of water; 2. identify the difference between samples of water from different sources; 3. purify a given quantity of water by a variety of methods; 4. list the uses of water.	1. Sources of water. 2. Purification or water - sedimentation, filtration, distillation. 3. Uses of water.	1. Set up simple experiment to illustrate dissolved substances in water, to establish solutions, suspensions, and colloids. 2. Purify various sample of water collected.
Man and Space	The child should be able to: 1. describe the earth, sun and moon; 2. explain the cause of day and night, and the seasons; 3. describe the solar system and relate the positions of the planets to the earth; 4. identify some groups of stars that can be seen over Nigeria; 5. recognise that the moon is a satellite of the earth; 6. recognise that the sun is a star.	1. The Earth, Sun, and Moon. 2. Climate and Seasons. 3. Solar system. 4. Stars.	1. Observe the moon and stars at night and identify the phases of the moon. 2. Demonstrate by simple experiments the rotation and revolution of the earth.

YEAR 2 Physical and Chemical changes.	The child should be able to: 1. state what is physical changes; 2. state what is chemical changes; 3. differentiate between physical and chemical changes.	1. Physical changes. 2. Chemical change.	Perform experiments to illustrate physical and chemical changes.
Elements, Compounds and Mixtures.	The child should be able to: 1. differentiate between elements, compounds and mixtures; 2. identify pure and impure substances; 3. extract salt from sea water or from salt water; 4. describe how petroleum is refined from crude oil; 5. separate alcohol from fermented palmwine.	1. Elements, compounds and mixtures. 2. Methods of separating mixtures, decantation, filtration, distillation, evaporation, sieving, chromatography, sublimation, etc. 3. Extraction of salt from sea water. 4. Petroleum - refining.	1. Prepare a mixture, a compound from their elements. 2. Carry out a simple experiment to illustrate methods of separation of mixtures. 3. Lead a discussion to distinguish between elements, compounds and mixtures.
Further investigation of Air and Water.	The child should be able to: 1. identify the part of air that supports burning; 2. estimate the proportion of air used up during burning.	1. Burning of substances in air. 2. Proportion of air used. 3. Laboratory preparation of oxygen.	1. Burn substances in air and estimate the proportion of air used in burning. 2. Prepare oxygen in the laboratory using hydrogen peroxide and manganese dioxide.
Hydrogen.	The child should be able to: 1. identify hydrogen; 2. prepare hydrogen; 3. state the properties of hydrogen; 4. state the uses of hydrogen; 5. demonstrate that water is a product of hydrogen and oxygen.	1. Preparation, properties and uses of hydrogen. 2. Water as product of hydrogen and oxygen - (a) synthesis of water from dry hydrogen and oxygen; (b) electrolysis of water to hydrogen and oxygen.	1. Prepare hydrogen in the laboratory using dilute sulphuric acid and zinc or magnesium. 2. Test for hydrogen. 3. Demonstrate lightness of hydrogen. 4. Burn hydrogen in air to form water. 5. Demonstrate the electrolysis of water.
Rusting.	The child should be able to: 1. explain what is rusting; 2. state the conditions for rusting; 3. compare rusting with burning and respiration; 4. state and describe methods of preventing rusting.	1. Rusting in nature. 2. Conditions necessary for rusting. 3. Rusting compared with burning and respiration.	1. Observe materials that rust. 2. Experiments to show conditions for rusting. 3. Discuss the methods of preventing rusting. 4. Compare rusting, burning and respiration.

Energy.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. explain the concept of energy; 2. state some of the different forms of energy; 3. identify and demonstrate some of the effects of heat; 4. state and describe some ways of producing heat and measure heat quantity; 5. measure the normal body temperature; 6. show understanding of the formation of shadows and eclipse; 7. recognise that the moon has no light of its own; 8. state and demonstrate some of the properties of light; 9. construct and describe a pinhole camera; 10. recognise mirrors, lenses and prisms; 11. show understanding of the dispersion of light by prisms. 12. recognise that the colour of a body is due to light reflected from it. 	<ol style="list-style-type: none"> 1. Concept or energy. 2. Sun as primary source of energy. 3. Forms of energy. 4. Heat energy - temperature, effects of heat, ways of producing heat. 5. Light energy. 6. Pinhole camera, eclipse, reflection of light, reflection of light. 7. Colour - Prism and production. 8. Absorption of light by coloured objects. 	<ol style="list-style-type: none"> 1. Illustrate the properties of different forms of energy. 2. Produce heat by rubbing hands together. 3. Use a clinical thermometer to measure body temperature. 4. Demonstrate formation of shadows and eclipse. 5. Demonstrate how the moon gets its light. 6. Construct the pinhole camera. 7. Perform simple experiments with mirrors, lenses, prisms. 8. Demonstrate light spectrum using prism.
Measurement	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. demonstrate the knowledge of S. I. units of some derived quantities; 2. distinguish between mass and weight. 	<ol style="list-style-type: none"> 1. Measurement of density, force, pressure, 2. Mass and weight. 	<ol style="list-style-type: none"> 1. Use hydrometer to compare densities of various liquids. 2. Use spring balance to measure force. 3. Use pressure gauge to measure pressure. 4. Use beam balance to measure mass. 5. Use spring balance to measure weight.
YEAR 3 Chemical Symbols and Formulae and Equations.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. understand the concept and definition of an atom and a molecule; 2. state the chemical symbols of elements; 3. write formulae of some common compounds; 4. write correct equations for some simple chemical reactions. 	<ol style="list-style-type: none"> 1. Atoms and molecules. 2. Chemical symbols of elements. 3. Formulae of compounds. 4. Simple equations. 	<ol style="list-style-type: none"> 1. Discuss concept of atoms and molecules. 2. Carry out experiments to confirm simple chemical formulae and equations. 3. Lead students in writing and balancing equations.

Atomic Structure.	The child should be able to: 1. infer atom concept from knowledge of the particulate theory of matter; 2. state the three main constituents of the atoms; 3. describe a simple atomic model; 4. explain the concepts of electrons, neutrons and protons.	1. Concept of electrons, neutrons and protons. 2. Simple atomic model.	1. Refer to experiments on particulate theory of matter and develop concept of atom from there. 2. Construct atomic model showing the relative positions of electrons and nucleus.
Metals and Non-Metals.	The child should be able to: 1. state the characteristics of metals and non-metals; 2. differentiate metals from non-metals; 3. describe how tin is extracted from its ore; 4. describe how iron is extracted from its ore; 5. describe how steel is manufactured; 6. state the differences between iron and steel; 7. recognise the uses of tin, iron and steel.	1. Characteristics of metals and non-metals . 2. Extraction of tin from its ore. 3. Extractions of iron from its ore. 4. Steel manufacture. 5. Uses if these metals.	1. Observe the physical differences between metal and non-metals. 2. Use magnets to distinguish between iron and steel.
Activity Series.	The child should be able to: 1. explain what are activity series; 2. arrange given metals in the order of their reactivity.	1. Action of water on metals (sodium, calcium, magnesium, iron, copper, etc.). 2. Action of dilute mineral acids on metals (calcium, magnesium, iron, lead, copper).	Observe rates of reaction of (a) water, (b) dilute acids on the metals, calcium, magnesium, iron, lead, copper. Caution !!!

Acids, Bases, and Salts.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. explain what are acids, bases and salts; 2. identify acids and bases; 3. use litmus paper to show the acidity or basicity of a given solution or liquid; 4. understand the concept of neutralisation; 5. prepare simple salts. 	<p>1. Acids in nature.</p> <ol style="list-style-type: none"> 2. Tests for acids and bases. 3. neutralisation. 4. Preparation of simple salts. 	<p>1. Tests for acids in nature .</p> <ol style="list-style-type: none"> 2. Burn some elements in oxygen and test their solutions for acidity and basicity. 3. Prepare simple salts in the laboratory by neutralisation, synthesis, acid on metal oxides or metal carbonates by double decomposition.
Energy conversion and Transfer.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. make a simple cell and use it to demonstrate the conversion of chemical energy to electrical energy; 2. identify substance which conduct electricity and those that do not; 3. show understanding of some basic facts about current and resistance in simple d.c. circuit; 4. identify those that conduct heat and those that do not; 5. state three ways by which heat can be transferred; 6. describe conduction, convection and radiation of heat, and give examples of each; 7. state how sound is produced; 8. demonstrate that sound requires a material medium for its transfer; 9. recognise sound as a wave motion; 10. describe what is an echo; 11. distinguish between noise and music; 12. identify some musical instruments. 	<p>1. Chemical energy to electric energy - the simple cell.</p> <ol style="list-style-type: none"> 2. Conductors and insulators. 3. Electrical energy - simple electrical circuits. 4. Heat energy - good and bad conductors, conduction, convection, radiation. 5. Sound energy - mechanism of transferring sound. 6. vibrations, echoes, noise, music. 	<p>1. See objective (1)</p> <ol style="list-style-type: none"> 2. Connect in series, a battery , torch light bulb using a conductor and non- conductor in turns. 3. Dip an iron rod and a wooden rod in turn in steam and feel the free end. 4. Carry out simple experiments to illustrate conduction, convection and radiation. 5. Carry out a simple experiment to show that a medium is necessary for transfer of sound. 6. Carry out simple experiments to illustrate sound as a wave motion and that it can be reflected. 7. Discuss sound reflection, echoes and musical instruments.

Energy and Work.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. relate the concepts of energy and work to inter-conversion of energy; 2. state devices where energy conversion is prevalent. 	<p>Inter-conversion of energy as seen from various machines or mechanical set up such as in:</p> <ol style="list-style-type: none"> 1. hydroelectricity; 2. steam engine; 3. bicycle; 4. Telephone; 5. Accumulators; 6. Diesel engine; 7. Motors. 	<p>Demonstrate or discuss the use of these devices in every day life and point out the different energy conversions that take place.</p>
Kinetic Theory.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. state some of the basic assumptions of the kinetic theory ; 2. relate the particulate theory to kinetic theory; 3. use the kinetic theory to explain some phenomena. 	<p>Simple qualitative aspects of the kinetic theory - it assumptions and its use in explaining some phenomena e.g. evaporation, boiling, pressure.</p> <ol style="list-style-type: none"> 1. Space travel. 2. Gravitational pull. 	<p>Discuss theory, using the particulate theory of matter as the starting point. Perform simple experiments to illustrate kinetic theory.</p>
Man in Space.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. recognise that the moon has no light of its own, the sun being responsible for moonlight; 2. explain the concept of gravitational pull and how it enables objects (say the moon) to move round the earth. 		<p>Demonstrate rocket(jet) propulsion with a balloon.</p>

5. THEME: SAVING YOUR ENERGY.

YEAR 1 Science-Related Occupation.	The child should be able to: 1. identify occupations that are science-related; 2. recognise the work experiences that are related to these occupations; 3. identify the science involved in the performance of some duties connected with these occupations.	Examples and work description of farming, fishing, carpentry, engineering, medicine, etc.	Draw on the experiences of the pupils in a classroom discussion, describe and explain duties related to a variety of occupations pointing out those that are directly related to science application.
Tools (Machines) for Work	The child should be able to: 1. identify basic tools used by personnel on science-related occupations; 2. describe and operate some of these tools; 3. recognise and state the improvement introduced by the use of the tools above.	Examples and description of some basic tools used by farmers, fishermen, carpenters, auto mechanics, auto-electricians, medical doctors, nurses; etc. comparison of traditional and modern mechanically and electrically powered tools.	Trip to appropriate practitioner of these occupations for identification and examination of relevant tools, actual practice in the use of some tools e.g. hoes, cutlasses, saws, hammers, wood planers, drills, screwdrivers, jacks. Lead discussion on child's experiences of similar labour saving devices e.g. grinding with stones and modern grinders with mechanical and electrical modern grinders.
Force.	The child should be able to: 1. explain the concept of force and measure gravitational force on a given mass; 2. identify the presence of a force, especially a force field; 3. identify the presence of a balanced or an unbalanced force; 4. recognise that forces always occur in pairs; 5. identify and describe situations where friction is in use; 6. explain the cause of motion.	1. Concept of force. 2. Types of force contact force e.g. push, pull, friction, force field e.g. gravitational, electric, magnetic. 3. Balanced and unbalanced forces. 4. Friction in use, advantages of friction especially its use in walking.	1. Identify the presence of forces. 2. Detect balanced and unbalanced forces leading to conclusion that forces occur in pair and that unbalanced forces cause motion. 3. Measure gravitational forces on given masses using a calibrated spring balance. 4. Lead a discussion to show that without friction, one will never be able to walk; compare motion of car on wet slippery road and on dry road.
YEAR 2 Force	7. identify and describe effects of a force; 8. recognise that a force is always required to maintain or change the state of motion of a body.	Effects of force.	Perform experiments to show that: 1. motion occurs in the direction of an applied force; 2. force can change the direction of motion of a body; 3. a force is necessary to slow down, stop, or speed up motion.

Simple Machines.	The child should be able to: 1. identify what constitutes a simple machine; 2. apply the principle of simple machine to do work; 3. identify the essential parts of a lever and use the arrangement of these parts to classify levers.	Types of machine - the lever, inclined plane, pulley, screw, and wedge.	1. Perform simple activities to show why simple machines are necessary for doing work e.g. using pliers to cut a nail, hammer to drive a nail into a wood or pull a nail from wood. Use of pulley to lift weight. 2. Experiment with an inclined plane to show that less force is required to lift object to same height as when lifted directly without using the simple machine.
Maintenance of Machines.	The child should be able to recognise the: 1. necessity for regular maintenance of machines; 2. need to reduce friction in the moving parts of a machine; 3. Use of grease, oil, ball-bearings in reducing friction.	1. Importance of regular maintenance of machines. 2. Need to reduce friction in machines. Use of grease, oil, ball-bearings to reduce friction.	1. Perform simple experiments to show the effect of oil on two bodies in relative motion. 2. Make trip to a carpenter's or auto mechanic's workshop to see use of oil in reducing friction in action. 3. Discuss regular maintenance of machines.
YEAR 3 Work and Energy.	The child should be able to: 1. recognise that work is done only if a force causes a displacement; 2. calculate the work done when a given force moves an object through a known distance in direction of the force; 3. recognise that energy is required in doing work, that machines transfer energy when they do work; 4. recognise that no machine is perfectly efficient; 5. state the energy changes that occur when work is done; 6. recognise the presence of other forms of energy during the conversion of one form to the other.	1. Concept of work and of energy. 2. Human and non-human means of doing work; 3. Mechanical advantage. Efficiency of machine. Energy unavailable for desired work. 4. Potential to kinetic energy as an example in human means of doing work. 5. Electrical to mechanical and mechanical to heat energy as examples in non-human means of doing work.	1. Perform simple experiments to calculate work done from measurement of applied force and displacement. 2. Perform simple experiments to show potential (stored) energy being converted to kinetic energy to do work. 3. Demonstrate that not all energy put into a machine is available to do external work hence no 100% efficiency. 4. Experiment with the lever to show mechanical advantage and hence conclude that the lever is a force multiplier. 5. Drawing on children's experience discuss how the use of stored energy in the body to do 'work' amounts to converting potential energy to kinetic energy (not 100% conversion!). 6. Perform simple experiments on the conversion of mechanical to heat energy e.g. rubbing of palms or metal or any two substances to produce heat. 7. Draw attention to heat on tyres and engine of cars soon after a long drive.

6. THEME: CONTROLLING THE ENVIRONMENT.

YEAR 1 Environmental sanitation.	The child should be able to: 1. list the ways in which the community can dispose of refuse; 2. list the ways in which individuals can assist the community in the above; 3. participate in keeping the school environment clean and healthy; 4. distinguish between biodegradable and non-biodegradable refuse; 5. compare traditional treatment of refuse in town and village.	1. Community disposal of refuse in villages and towns. 2. The balance of nature in the villages. 3. Compost.	1. Collect refuse in school yard. 2. Separate refuse into groups of those that are biodegradable and those that are not. 3. Record the time needed for substances to decompose.
Sewage.	The child should be able to: 1. list different ways of disposing of sewage in towns and villages; 2. list the reasons for the community's responsibility for disposal of sewage.	Sewage: outdoor latrines, flush toilets- necessary for water system.	1. Lead a discussion on treatment and disposal of sewage in a town and a village and make a list comparing the effect of each system on environmental sanitation. 2. List conditions necessary for the introduction of flush toilets.
Disease Vectors. (a) The female Anopheles Mosquitoes. (b) Flies: the Housefly, the Black fly, the Tsetse-fly.	The child should be able to: 1. describe the life cycle of the anopheles mosquito; 2. control the breeding of mosquitoes and the of malaria. The child should be able to: 1. describe the life cycle of the housefly, the black fly and the tsetse-fly; 2. identify the parts of the housefly that may carry germs.	1 Disease vectors. 2. Life cycle of the mosquito. 3. Water drainage. 4. Insecticides. 5. Oil spreading/spraying. 1. Life cycle of housefly, black fly, and tsetse-fly. 2. flies as germ carriers. 3. River blindness and sleeping sickness.	1. Collecting water from a near by pond to watch and observe the life cycle of the mosquito. 2. Identify ways in which the mosquito can be controlled by the community. 3. Using a diagram provided, write a description of how the plasmodium gets into our blood. 1. Observe and draw the structure of the housefly locating parts of the housefly's body that carries germs. 2. Leave a piece of boiled meat in a covered and uncovered jar and observe uncovered jar, observe life cycle. 3. Answer questions from charts on the life cycle of black fly and tsetse fly.

Preventive Medicine: (a) Clean Water (b) Immunizations	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. identify the necessity for boiling water taken from streams and ponds; 2. list the advantages of the government providing pipe-borne water. <p>The child should be able to:</p> <ol style="list-style-type: none"> 1. list the diseases that can be prevented through immunization; 2. locate the places in his community where immunization is available; 3. find the percentage of the class that is immunized against smallpox and discuss the likelihood of smallpox attacking anyone in the class. 	<ol style="list-style-type: none"> 1. Cholera. 2. Diarrhoea, 3. Typhoid. 4. Pipe-borne water. 5. Water treatment processes. <ol style="list-style-type: none"> 1. Vaccination. 2. Inoculations. 3. The conquering of smallpox in Nigeria. 	<ol style="list-style-type: none"> 1. Tell a 'mystery' story that traces the sources of a health problem to drinking water. 2. Collect health records of two villages, one with pipe-borne water, noting the relative number of cases of cholera, diarrhoea, dysentery and typhoid. <p>Take a survey - counting those immunized against smallpox in the school or community.</p>
Maintaining Balance in the Environment.	The child should be able to recognise factors that control population growth.	Effects of limited and unlimited growth.	<ol style="list-style-type: none"> 1. Grow bean weevils in a jar in a limited amount of beans and count the number of adult weevils at time intervals. 2. Make a graph of the observation. 3. Lead a discussion on the findings and relate to human population growth.
Wildlife Conservation.	The child should recognise the need for wildlife conservation.	<ol style="list-style-type: none"> 1. Man's activities are reducing the number of wildlife. 2. wildlife role in a balanced environment relates to the well-being of other organisms and man. 3. Wildlife reserves in Nigeria. 	<ol style="list-style-type: none"> 1. Lead discussion on need to conserve wildlife. 2. Discuss the methods of wildlife conservation practised in Nigeria. 3. Where possible, visit a game reserve.
Air Pollutants.	<p>The child should be able to:</p> <ol style="list-style-type: none"> 1. distinguish between air-borne solids and gases that pollute the air; 2. recognise that low sulphur fuel, as found in Nigeria, causes less pollution. 	<ol style="list-style-type: none"> 1. Kinds of air pollutants and their effects. 2. Nigeria's crude oil is low in sulphur content and is desirable world-wide. 	<ol style="list-style-type: none"> 1. Collect air-borne solid particles on greased slides for one day, and observe the quantity of particles. 2. Discuss the importance of low sulphur petroleum in the world economy.

Water Pollutants.	The child should be able to: 1. identify water pollutants and their effects; 2. recognise how water pollutants can be controlled.	1. Pollutants from the home. 2. Pollutants from industry and agriculture. 3. Effects and control of water pollution.	1. lead a discussion on pollutants in water supplies. 2. Perform a simple experiment on effect of pollutant on aquatic life.
Erosion	the child should be able to observe the role of living things in causing and preventing erosion.	Causes and prevention of erosion.	1. Perform simple experiments to illustrate the causes and prevention of erosion. 2. Visit nearby erosion site and take/observe steps to control the erosion.
Flooding.	The child should be able to: 1. observe the drainage patterns around the community after a rain; 2. discuss the cumulative effects during rainy season.	1. Drainage patterns. 2. Causes of flooding. 3. Prevention of flooding.	1. Draw maps of the community showing drainage patterns. 2. Use a map of an area which floods; draw inferences to explain the flooding.
oil Spillage and Burning of Natural Gas.	The child should be able to: observe that there are some problems involved in the search, production and transportation of oil.	The effect of oil spillage and burning of natural gas on the environment.	with the aid of a chart, film or book, discuss effects of oil spillage and burning of natural gas on the environment.
YEAR 3 Our Disappearing Forests.	The child should be able to: 1. calculate the amount of firewood (in kg) that is used by a family in a year and make an inference about the effect of the use of firewood on our forest; 2. compare the cost of using firewood to using kerosene or gas or electricity (cooking with sunlight); 3. lists uses of timber; 4. list ways in which our forests can be preserved.	1. Mature forests are almost non-existent in West Africa today due to human activities. 2. Encroaching deserts. 3. Other fuels shall be used for cooking. 4. Replanting our forests.	1. By a visit to a local market and class discussion, estimate the amount of wood in (kg) used by a family in a day, a month and a year. 2. Given the mass of a tree, find the number of trees that a family burns in a year and hence the number of trees required for a given local community. 3. Lead a discussion on deforestation, afforestation and reforestation. 4. Discuss use of other fuels e.g. kerosene, gas and electricity, and costs.
Controlling the weather.	The child should be able to: 1. list the variables involved in the production of weather; 2. operationally define humidity, precipitation, haze and wind direction.	1. Simple conditions of weather- temperature, humidity, barometric pressure, kinds of clouds, precipitation, haze, visibility, storms, lightning and thunder. 2. Weather maps - wind direction, isobars, etc.	1. Keep a record of temperature variations during the day and make a graph showing the changes. 2. find the humidity, air pressure and wind direction for that day.

APPENDIX H

NIGERIAN INTEGRATED SCIENCE TEACHER EDUCATION PROJECT (NISTEP).

SYLLABUS FOR INTEGRATED SCIENCE (DOUBLE MAJOR) AT NCE LEVEL

Conforming with the National Minimum Standards as published by the National Commission for Colleges of Education (NCCE), 1991.

PREAMBLE.

Introduction.

This syllabus, in semester format, is based upon the Double Major Integrated Science Syllabus (year format) approved by the Board of Studies, Institute of Education, ABU,, in September 1989. Science, of course, forms the major component of the programme in all the three parts of the NCE double major course. The mathematics and methodology units form an integral part of the double major syllabus, and are covered in Parts I and II of the course.

Science

Year I is seen as a foundation year in the basic sciences. Given the varied entry qualifications of candidates, in terms of science content, flexible approach is envisaged with a view to bringing all candidates to a common level of familiarity and understanding with the three major areas of science.

Parts II and III of the course will see an expanding of the content are of the basic sciences and this will be done with constant reference to unifying concepts such as energy, conservation, balance and cycles in nature, particle theory, and fields of study such as health, technology and ecology. It is this emphasis on the unity of the scientific world view which will make this programme different from a mere combination of topics from physics, chemistry and biology.

The programme emphasises throughout a view of science as a field of study whose seen as consisting simply of an established set of facts and laws. Indeed, the detailed content syllabus which follows should be seen as a bare skeleton. In order for it to come to life, it must be fleshed out with the processes of scientific thinking and practical skills, and the social relevance of the applications of science.

Processes

"Science" is far more than an inert body of knowledge. It is method of enquiry into the nature of the environment. This method can be learned by anyone, and a prime aim of any science curriculum must be to provide students with an introduction to this methods, to allow them to follow their own enquiries. The method of enquiry has cognitive and practical aspects.

The cognitive aspects include the ability to formulate questions, to identify variables and design experiments, to interpret results, recognise patterns, general^e/hypotheses, draw conclusions and develop theoretical models.

Skills

The practical skills required if one is to pursue scientific enquiry include general skills, such as the ability to observe and to measure, and more specialised skills in the handling and use of laboratory apparatus, living material and chemicals.

Applications

Science is also very much more than an academic method of study, using strange symbols and sophisticated apparatus removed from the real world. The application of the science knowledge and concepts contained in the detailed syllabus to the everyday experience of the students and to the technological development of Nigeria must be emphasised throughout.

It should be taken as mandatory in this syllabus that these elements of processes, skills, and applications are to be woven the content matter as often as they can be.

Conclusion

The method by which trainee teachers are introduced to the content and processes of science should itself conform to the model of good practice it intends to propagate. ;To this end there should be an emphasis on learning science by the students (as, we hope, by pupils in schools) through:

- discussing their own ideas.
- using activity based methods (heuristic approach).
- developing appropriate processes and skills.
- improving their written and oral communication skills.

These four learning actions are appropriate at all levels of science education and it is the responsibility of both college lecturers as well as school teachers, to manage the learning environment so as to achieve them.

Course Requirements for NCE Double Major Integrated Science.

NCE YEAR I

First Semester

Course Title	Credits	Hours/Week
ISC 110 Mathematics for Science I	1 unit	1 hour
ISC 112 Science Education I	2 units	2 hours
ISC 113 Introduction to Scientific Methods	2 units	4 hours
ISC 114 Components of the Environment I	3 units	5 hours
ISC 115 Man and Energy I	3 units	4 hours
ISC 116 Nature of Matter I	2 units	4 hours
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Total:	13 units	20 hours.

Second semester

ISC 120 Mathematics for Science II	1 unit	1 hour
ISC 122 Science Education II	2 units	2 hours
ISC 123 Processes of Life	3 units	4 hours
ISC 124 components of the Environment II	3 units	4 hours
ISC 125 Man and Energy II	3 units	5 hours
ISC 126 Transport, Control & Develpt. in living things	1 unit	2 hours
ISC 127 The Earth and the Moon	1 unit	2 hours
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Total:	14 units	20 hours

NCE YEAR II

First Semester

ISC 210 Mathematics for Science III	1 unit	1 hour
ISC 212 Science Education III	2 units	2 hours
ISC 213 Man in the Environment	3 units	4 hours
ISC 214 Nature of Matter II	2 units	4 hours
ISC 215 Statics and Dynamics	3 units	5 hours
ISC 216 Energy and Particles	3 units	4 hours
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Total:	14 units	20 hours

Second Semester.

ISC 220 Mathematics for Science IV	1 unit	1 hour
ISC 222 Science Education IV	2 units	2 hours
ISC 223 Metals	3 units	4 hours
ISC 224 The Earth in the Universe	1 unit	2 hours
ISC 225 Fundamentals of Living things	3 units	4 hours
ISC 226 Man and Energy III	3 units	5 hours
ISC 227 Reproduction and Growth	1 unit	2 hours
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Total:	14 units	20 hours

NCE YEAR III**First Semester**

ISC 311 Carbon compounds I	1 unit	7 hours
ISC 312 Transport, control & Develpt in Living things II	1 unit	7 hours
ISC 313 Global Ecology I	1 unit	6 hours
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Total:	3 units	20 hours (for 4 weeks)
Teaching Practice	10 units	(10 weeks)

Second Semester

ISC 321 Environmental and Population	2 units	3 hours
ISC 322 Science and Society	2 units	3 hours
ISC 323 Chemical Energetics	3 units	4 hours
ISC 324 Transport, control & Develpt. in Living things III	2 units	3 hours
ISC 325 Fields and Waves	2 units	3 hours
ISC 326 Carbon Compounds II	2 units	3 hours
ISC 327 Global Ecology II	1 unit	1 hour
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Total:	14 units	20 hours

Overall Course Total: 72 units + 10 units T.P.

COURSES FOR THE NCE IN INTEGRATED SCIENCE.

THEME	TOPIC	CONTENT
ISC 110 & 120: MATHEMATICS FOR SCIENCE. (YEAR 1)	Arithmetic.	<ul style="list-style-type: none"> - Use calculating aids such as tables and electronic calculators for the four arithmetic functions, plus reciprocals, square roots, sines, cosines, tangents, exponentials and logarithms. - take account of accuracy in numerical work so that significant figures are neither lost, nor carried beyond what is justified. - make approximate evaluations of numerical expressions (e.g. $2 = 10$; $\sin 30 = 0.5$) and use such approximations to check the magnitude of machine calculations. - change the subject of an equation, also involving positive and negative indices, and square roots. - solve simple algebraic equations, linear equations and quadratic equations, using the correct formula.
	Algebra	<ul style="list-style-type: none"> - Translate information between graphical, numerical, algebraic and verbal forms. - select appropriate variables and scales for graph plotting determine the slope and intercept on a linear graph. - recall the standard linear form $y = mx + c$ and re-arrange relationships into linear form where appropriate. - sketch and recognise the forms of common plots such as $1/X$, X^2, $1/X^2$, $\sin X$, $\cos X$ e^{-X}. - understand and use the slope of a tangent to a curve as a means of obtaining gradient.
	Graphs I	<ul style="list-style-type: none"> - calculate areas of right angle and isosceles triangles. - calculate circumferences and areas of circles and segments. - calculate areas and volumes of rectangular blocks, cylinders and spheres. - use Pythagoras' theorem, similarity of triangles and angle sum of a triangle. - use sines, cosines and tangents in physical problems. - recall, or quickly calculate the values at 0°, 30°, 45°, 60° and 90°. - recall that $\sin \theta = \tan \theta = \theta$; and that $\sin^2 \theta + \cos^2 \theta = 1$. - understand the relationship between degrees and radians and be able to translate from one to another.
(YEAR 2)	Vectors.	<ul style="list-style-type: none"> - find the resultant of two co-planar vectors. - find expressions for components of vectors in perpendicular directions and recognise conditions where vector resolution is appropriate.
	Graphs II.	<ul style="list-style-type: none"> - revise from ISC 120 the use of the slope of a tangent or a curve as a means of obtaining gradient; e.g. distance/ time graphs. - understand and use d/dx for a rate of change with respect to variable x. - understand and use the area below a curve and relate this to integration, e. g. velocity / time graphs. - use histogram plots, smoothing where necessary. - apply the wave equation to simple harmonic motion, AC generation, wave interference and , diffraction.
	Calculus.	<ul style="list-style-type: none"> - differentiate kx^n, $\sin kx$, $\cos kx$ - integrate kx^n, $\sin kx$, $\cos kx$. - understand the graphical means of differentiation and integration. - determine maxima and minima.

	Statistics.	<ul style="list-style-type: none"> - determine the range, mean, median and mode of a set of values. - understand the concept of dispersion and standard deviation. - understand the concept of correlation. - understand the normal distribution curve, probability, tests of significance. - apply the above to practical situations.
ISC 113 INTRODUCTION TO SCIENTIFIC METHODS. (YEAR 1)	Observation.	<ul style="list-style-type: none"> - name the various senses and the related organs. - use the various senses to make and record observations. - name, describe and use aids to the senses such as the microscope, hand lens, telescope, glasses, hearing aid (details of how they work are not required).
	Measurement.	<ul style="list-style-type: none"> - name the standard SI units and common related units for measurement of length, area, volume, mass, temperature and time.
	Classification.	<ul style="list-style-type: none"> - name, describe and use the correct apparatus and instruments for measurement in the units specified in above. - group or classify objects observed in the environment by colour, shape, behaviour and other observed criteria. - describe the main scheme for classifying living things: plants and animals; vertebrates and invertebrates; groups of vertebrates; flowering and non-flowering plants.
	Safety in the environment.	<ul style="list-style-type: none"> identify safety measures in using appliances in the home, school, work place, etc. - identify safety measure in using road, rail, and other transport systems - know ways of extinguishing fires, including oil and electrical fires. - know first aid for victims of electric shock, acid/alkali burns and other common accidents.
ISC 114 & 124 COMPONENTS OF THE ENVIRONMENT. (YEAR 1)	Air.	<ul style="list-style-type: none"> - describe one method for determining experimentally the proportion of oxygen in the atmosphere . - state the qualitative and quantitative composition if air in terms of nitrogen, oxygen, water vapour, inert gases and carbon dioxide. - describe the physical properties and uses of oxygen and carbon dioxide and their importance to living things.
	Water.	<ul style="list-style-type: none"> - identify the various sources of water . - describe the importance of water to life. - understand the nature of water as a solvent. - explain the importance of oxygen dissolved in water. - identify some sources of water contaminating agents, (e.g. sewage, oil, chemicals). - explain methods of water purification (e.g. use of chemicals, filtration, boiling, sedimentation). - discuss and compare rural and urban water supplies. - outline the water cycle, including the formation of ice, thunder and lightning, non-uniform rainfall, rainbows. - describe the effect of rainfall on the environment, with respect to plant growth and erosion.
	Weather.	<ul style="list-style-type: none"> - identify and describe the elements of weather (temperature, humidity, wind, rain, etc.) - describe and use simple weather recording instruments in a weather station) thermometer, rain gauge, wind vane, barometer, hygrometer, etc.) - keep weather records in chart form.

	Soil.	<ul style="list-style-type: none"> - identify organisms that live in soils in your environment - explain the mineral skeleton of the soils: soil texture, inorganic and organic components, air content and water. - describe the formation of soil in the light of climate and weathering, parent material, topography, organisms, influence of man and time. - recognise types of soil: sandy, clay, loam, humus, etc. - appreciate the value of soil as a non-renewable resource. - describe the common causes and forms of soil erosion and the relevant preventative measures. - discuss effects of bush burning and indiscriminate use of fertilisers.
	Characteristics of living things.	<ul style="list-style-type: none"> - outline the characteristics of living things. - explain the principles of classification of plants and animals. - devise and use simple keys.
	Plant and Animal Cells.	<ul style="list-style-type: none"> - prepare cheek cells and onion cells for viewing under a microscope. - recognise and distinguish between animal and plant cells e.g. cytoplasm, cell wall, cell membrane, nucleus, vacuoles and chloroplasts in a plant cell; cytoplasm, cell membrane and nucleus in an animal cell.
	Chromosomes and Genes.	<ul style="list-style-type: none"> - understand that nuclei contain chromosomes and that chromosomes carry genes. - understand that genes carry chemical information which determines an individuals' characteristics.
	Bacteria and Viruses.	<ul style="list-style-type: none"> - know that bacteria and viruses are micro-organisms. - understand that bacteria and viruses are important members of ecological cycles. - explain the importance of bacteria in natural water. - know that viruses and some bacteria can cause disease. - use some bacteria e.g. to make yoghurt and cheese.
	Fungi.	<ul style="list-style-type: none"> - recognise fungi and state their characteristics. - give examples of the occurrence of fungi, their use as food and in industry.
ICS 115, 125 & 226: MAN AND ENERGY. (YEAR 1)	Force, Work, Energy, Power.	<ul style="list-style-type: none"> - measure forces using a newton meter. - know that work done = force x distance, and is measured in joules. - know that the energy of a body is a measure of its capacity to do work and is measured in joules. - understand the concept of power as the rate at which work is done (energy is transferred) and that the unit of power is the watt (joule/second). - apply the above to practical examples e.g. machines and movement in humans.
	Forms of Energy.	<ul style="list-style-type: none"> - distinguish between kinetic and potential energy, with kinetic energy associated with motion, and potential energy associated with position in a force field. e.g. gravity. - give examples and sources of each of the following forms of energy; chemical, heat, magnetic, sound, and electromagnetic radiation including light. - understand that energy can be converted from one form to another, e.g. electrical to sound, heat to mechanical. - apply ideas of energy conversion to machines, power stations and to animals (metabolism).

	Heat and Temperature.	<ul style="list-style-type: none"> - relate the heat of a body to the energy of movement of particles in it . - know that materials generally expand on heating. - understand the Celsius and Kelvin temperature scales and the concept of absolute zero of temperature. - know the meaning of fixed points , temperature interval and the use of different thermometric substances (e. g. alcohol, mercury) and other properties (e.g. electrical resistance) for temperature measurement.
	Heat Transfer.	<ul style="list-style-type: none"> describe heat transfer by conduction, convection and radiation. - describe simple demonstrations of the conduction of heat along good and poor conductors and cite daily life examples of the use of good and poor conductors. - describe simple demonstrations of the transfer of heat by convection, and cite daily life examples of the use of convection. - describe simple demonstrations of the absorption and emission characteristics of matt and* shiny surfaces with regard to radiant heat and describe experiments to compare these surfaces.
	Light.	<ul style="list-style-type: none"> - understand rectilinear propagation of light, shadows and eclipses. - understand the laws of reflection. - describe the position and nature of an image formed by a plane mirror. - describe the behaviour of light as it passes from one medium to another; apply this to the passage of light through lenses, converging and diverging. - understand something of the structure and function of the human eye. - apply the effects of lenses to the correction of eye defects and the microscope and projector. - describe and explain the dispersion of white light as it passes through a prism. - explain the occurrence of rainbows in terms of the dispersion of light by rain drops.
	Sound.	<ul style="list-style-type: none"> explain how sound waves may be produced, propagated and reflected in terms of longitudinal waves in a medium. - know the velocity of sound in air and a simple method of measurement . - know the factors which cause changes in the frequency of sound given out by vibrating strings, air columns and other objects; the application of this to musical instruments. - relate the pitch of a sound to its frequency and loudness to amplitude. - understand the idea of quality of sound. - describe the structure and function of the ear in terms of the vibration of the ear drum causing nerve impulses.
(YEAR 2)	Magnetism	<ul style="list-style-type: none"> - understand elementary magnetism by performing investigations with permanent magnets. - know how to make permanent magnets. - know the laws of magnetism. - know about lines of magnetic force illustrated with iron filings. - understand magnetic induction as the mechanism for magnetic attraction. - be aware of geomagnetism and the use of the magnetic compass. - understand what is meant by angle of dip, magnetic equator, magnetic North and South Poles.
	Electrostatics.	<ul style="list-style-type: none"> - investigate the phenomena of static electricity by rubbing different materials e.g. polythene and acetate rods. - investigate differences between static electricity and magnetism. - explain electrostatics in terms of electrons.

	Current electricity.	<ul style="list-style-type: none"> - understand the need for a complete circuit for electricity to flow. - name the parts of a simple circuit and describe their functions. - explain the terms electrical conductor, electrical insulator and describe common applications of both. - draw and recognise the components of electrical circuit, including cells (batteries), switches, lamps, resistors, ammeters and voltmeters; in series and in parallel. - understand that chemical energy is converted to electrical energy in an electrical cell. - construct and describe a simple electromagnet. - describe in simple terms the production of an electric current by means of the relative motion of a conductor and a magnet. - explain that the major source of energy for large-scale electricity production are the combustion of fossil fuels (e.g. Egham thermal power station), water-flow (e.g. Kainji dam) and nuclear reactions. - demonstrate an understanding of the terms (and units of) resistance (ohms), current (amperes) and potential difference (p.d. or voltage) - understand and use the relationship between voltage, current and resistance. - distinguish between direct and alternating current.
	Mains electrical circuits.	<ul style="list-style-type: none"> - describe the correct wiring of fused and unfused 3-pin plugs. - describe the action of electrical fuses and reasons for the choice of a particular rating of fuse for a particular use. - explain the principle of earthing appliances and other safety aspects of electrical circuits.
	Costing of electrical energy.	<ul style="list-style-type: none"> - know that $\text{watts} = \text{volts} \times \text{amperes}$ and perform simple calculations. - know that the commercial unit of electrical energy consumption is the kilowatt hour (kWh) and how to calculate the cost, e.g. using a NEPA bill.
ISC 116: NATURE OF MATTER. (YEAR 1)	States of Matter.	<ul style="list-style-type: none"> - appreciate some evidence for the existence of matter as particles. - describe the general physical properties of solids, liquids and gases. - describe the changes of state of water and other common materials. - explain the states of matter and changes in terms of simple kinetic theory. - understand the ideal gas laws, $pV = nRT$ and the effect of intermolecular forces on physical properties. - know that the vapour pressure of a pure liquid depends on temperature (qualitative treatment only). - appreciate that a liquid boils when its vapour pressure is equal to the external pressure. - know something of order in solids; the structure of NaCl as an ionic solid and carbon (diamond) and carbon (graphite) as macromolecular structures; plastics as polymers (cross-linked or not) and glasses as super-cooled liquids.
	Physical and chemical separation techniques	<ul style="list-style-type: none"> - describe the differences between physical and chemical changes and some non-aqueous systems. - describe the techniques and applications of distillations, evaporation, sedimentation, crystallisation, filtration and chromatography e.g. paper and column.
	Elements, mixtures and compounds.	<ul style="list-style-type: none"> - classify matter into elements, mixtures and compounds; and distinguish between them. - be able to classify, or gases at room temperature elements as metals or non-metals and as solids, liquids, or gases at room temperature.

(YEAR 2)	Atomic structure and the periodic table.	<ul style="list-style-type: none"> - describe the structure of the atom in terms of protons, neutrons, and electrons, each particle described in terms of its relative charges and mass. - understand that an element is defined by the number of protons in its nucleus. - understand the concepts of atomic number and mass number, related to the number of protons and neutrons in a nucleus. - explain isotopes in terms of variations of numbers of neutrons. - know the arrangement of electrons in "shells" (considered as energy levels, not as Bohr orbits) for elements Hydrogen to Krypton. - know that certain groups of elements have certain properties and reactions in common; account for these groups of elements in terms of similarities of arrangement of electrons. - describe the gradation of properties within groups (alkali metals and halogens), change in electro-negativity and oxidising/reducing properties down a group. - give examples of gradation of properties along period, such as metallic for the period Sodium to Chlorine. - give examples of ionic and covalent compounds with properties characteristic of their bond type. - know the identification reactions of the anions Cl^-, Br^-, I^- (aqueous silver nitrate); NO_3^- (brown ring test); CO_3^{2-} (dilute acid); and SO_4^{2-} (barium chloride). - know the reactions of the cation Ag^+, Cu^+, Cu^{2+}, Al^{3+}, Fe^{2+}, Fe^{3+}; with the ions OH^-, Cl^-, and NH_4^+ (aq), as illustrations of precipitation reactions, hydrolysis and substitution reactions of metal ions; their use in identification. - know the general characteristics of transition elements; coloured ions, variable oxidation states, paramagnetism, and their use as catalysts. - understand that transition element properties are related to having an incomplete subshell of electrons.
ICS 123 : PROCESSES OF LIFE. (YEAR 1)	Reactions of some ions	<ul style="list-style-type: none"> - describe photosynthesis in terms of plants trapping energy and using it with carbon dioxide and water to make carbohydrate. - demonstrate how to test leaves and storage organs for starch . - describe experiments which show that light, carbon dioxide and chlorophyll are necessary for photosynthesis. - discuss the importance of photosynthesis to life processes and the economy.
	Photosynthesis	<ul style="list-style-type: none"> - explain what is meant by combustion and respiration. - define oxidation and reduction as the additional removal of oxygen respectively. - identify oxidation reactions and oxidising agents in cases where oxygen has been added. - describe the reactions of oxygen with some common elements (e.g. carbon, hydrogen, magnesium, sulphur, zinc). - describe respiration in terms of the release of energy from the reaction of oxygen with food, forming waste products, carbon dioxide and water. - describe an experiment to measure the energy change during the burning of food. - identify by description and diagram the following parts of a mammalian respiratory system: nostrils, trachea, epiglottis, bronchi, bronchioles, alveoli, lungs, capillaries, ribs, intercostal muscles, diaphragm; and describe the roles these parts play in bringing oxygen to the blood and removing carbon dioxide and water. - discuss the evidence which indicates that cigarette smoking is harmful.
	Combustion and Respiration.	

	Nutrition	<ul style="list-style-type: none"> - know different types of food and be able to test for the presence of glucose, starch, protein and fats. - give examples and sources of carbohydrates, fats and proteins; briefly describe their importance to animals and plants. - know some sources of calcium, iron and vitamins; briefly describe their importance to animals
	Digestive systems.	<ul style="list-style-type: none"> - describe digestion as the process of making large particles small enough to be soluble; illustrate this by reference to the physical and chemical action of teeth, gut muscles, digestive juices and enzymes. - identify by description and diagram of the digestive system of mammals: mouth, oesophagus, stomach, liver, small intestine, large intestine (colon and rectum), anus and the origin of the bile duct and pancreatic duct.
ICS 126: TRANSPORT, CONTROL AND SKELETAL SYSTEMS	Circulatory systems.	<ul style="list-style-type: none"> - understand the role of blood in the transport of foodstuffs, respiratory gases, hormones, heat, excretory materials and as a defence against diseases. - outline the role of lymph in the transport of foodstuffs. - outline the composition of blood and lymph. - describe the blood circulation of a mammal and how one way flow is maintained and how the structure of arteries and veins is related to their function. - describe the structure and function of the mammalian heart.
	Excretion.	<ul style="list-style-type: none"> - understand the process of excretion and describe the excretory organs and their functions in plants and mammals. - distinguish between excretion and elimination in mammals.
	Nervous system.	<ul style="list-style-type: none"> - describe the structure and function of the gross nervous system. - appreciate the value of the sensory nervous system in detection of the environment and protection.
	Skeletal system.	<ul style="list-style-type: none"> - describe the structure and function of the skeleton in support, movement and protection. - understand muscles as energy converters. - relate bones and joints to lever systems.
	Gain and loss of foods and other materials.	<ul style="list-style-type: none"> - review from ICS 123, food requirements, including classes of foods, and balanced diet for the mammals, digestion. - understand root systems in relation to exchange of materials; root structure and growth in a herbaceous dicotyledonous plant in relation to water and soil, nutrients and salts. - understand leaf and stem structure (cuticle, stomata, lenticels, internal and space system) in relation to the exchange of oxygen and carbon dioxide and loss of water vapour.
ICS 312 & 324: TRANSPORT, CONTROL & DEVELOPMENT IN LIVING THINGS. (YEAR 3)	Transport in flowering plants.	<ul style="list-style-type: none"> - review from ICS 124 & ICS 225, the physical processes in cells, including permeability and osmosis. - know the structure and arrangement of xylem and phloem tissues in relation to infraction in transport; evidence for transport in xylem and phloem. - know how water, minerals (potassium, phosphorus, calcium) and organic compounds (carbohydrates and organic nitrogen compounds) are carried by transport systems and distributed in the plant. - discuss hypotheses involving active diffusion.

	Reproduction.	<ul style="list-style-type: none"> - review from ISC 227 cyclic changes in the ovary & uterus and their relation to hormone release. - know the structural and functional differences between male and female gametes; the role of testosterone in sexual differentiation. - know the roles of the male and female reproductive tracts in coitus and capacitation. - enumerate some causes of infertility in males and females. - be aware of possibilities of determining the sex of the zygote. - distinguish between monozygotic and dizygotic twins. - appreciate the role and importance of foetal membranes; amnion, chorion and allantois. - understand the structure and function of the placenta and its limitation as a barrier, the vulnerability of the foetus. - be aware of the importance of blood tests; practical application of blood groups.
	Population and genetics.	<ul style="list-style-type: none"> - review the work on genetics in ISC 225. - understand the concept of herediability and the relevance of twin studies. - understand the principles of gene segregation and independent assortment. - know some general applications of genetics e.g. blood groups. Down's syndrome, sickle cell anaemia. - be aware of the possibilities of genetic engineering in the production of medical products.
	Development and growth.	<ul style="list-style-type: none"> - know the main factors associated with growth. - understand growth patterns of the body system in terms of height and weight, growth curves: differences in growth patterns of males and females. - be aware of the characteristics associated with puberty. - describe the changes and signs that occur associated with menopause. - understand senescence as a progressive inability to respond to changes in the environment, degeneration of the lymphatic system and decreased functioning of the organs, skeletal changes, osteoporosis and osteoarthritis: calcification of tissue relating to malfunctioning of arteries, lungs and eye lens. - appreciate that many of the changes that occur with age are natural and may require support and sympathy.
ISC 127: THE EARTH AND THE MOON.	Natural cycles	<ul style="list-style-type: none"> - describe and explain natural cycles - days, lunar months, years. - describe and explain the phenomena of seasons; harmattan; monsoons; summer/winter; rainy/dry.
	The Earth	<ul style="list-style-type: none"> - describe the structure of the Earth in terms of core mantle and crust. - appreciate the geological time scale and how it has been determined. - discuss the atmosphere as protection from radiation. - classify rocks as igneous, sedimentary and metamorphic. - understand how these types of rock are formed. - give details of the rock cycle. - test for some common rocks e.g. carbonates, sulphides. - know about the occurrence, value and use of minerals in Nigeria.
	The Moon	<ul style="list-style-type: none"> - know the relationship between the Moon and the Earth. - describe and explain the phases of the Moon. - describe conditions on the lunar surface. - understand how solar and lunar eclipses occur.

ISC 213: MAN IN THE ENVIRONMENT. (YEAR 2)	Human beings as higher animals.	<ul style="list-style-type: none"> - identify the characteristics of primates; the similarities and differences with other mammals. - distinguish human beings from other primates, describe differences such as skeletal structure, size of brain, manipulation and use of tools, language and intelligence. - explain the concept of an ecosystem . - describe the major ecosystems in Nigeria; deciduous, savannah and tropical forests. - describe the physical and biotic factors and uses of smaller ecosystems e.g. ponds, streams, farmland etc. - identify the relationships between plants and animals, food chains, food webs. - outline people's use of land with reference to food production and food chains. - explain the carbon and nitrogen cycles. - explain the importance of fertilizers , herbicides and pesticides in food production. - describe and explain the major traditional and modern methods of food preservation. - describe associations, parasitism, symbiosis and commensalism.
	Introductory Ecology.	<ul style="list-style-type: none"> - identify and describe the areas of exploitation of resources by man, such as deforestation, mining. - identify and describe some causes of environmental pollution; biological (sewage), chemical (especially fertilizers and power station emissions), thermal and others e.g. oil spillages, silt and other wastes from mining. - describe parts of the environment affected by pollution; land, air and water (rivers, lakes, the sea and piped water). - relate the transfer of pollutants to the food chain, resulting in concentration in carnivores; the particular danger to large predators.
	Influence of Man.	
	Conservation.	<ul style="list-style-type: none"> - identify and locate natural resources and their use in Nigeria. - describe what is meant by conservation and recycling of natural resources. - discuss the role of conservation organisations at local, national and international levels. - apply the knowledge acquired to improve the management of the environment.
ISC 215: STATICS AND DYNAMICS (YEAR 2)	Statics	<ul style="list-style-type: none"> - differentiate between scalar and vector quantities. - add and subtract coplanar vectors graphically or by calculation (resolution). - know and apply the conditions for equilibrium for two or three coplanar forces acting at a point. - understand the concept of moment of force about a point; couples, centre of mass and levers. - know and apply the principle of moments to the equilibrium of simple structures. - understand the concept of machines and be able to calculate mechanical advantage, velocity ratio, efficiency. - understand the concept of friction, its advantages and disadvantages with regard to the efficiency of machines e. g. lubrication, roller bearings and synovial fluid. - understand the concept of pressure as force/ area and apply this to knives, tires, caterpillar tracks etc.
	Fluids.	<ul style="list-style-type: none"> - understand the concept of density as the mass of a certain volume. - use the concept of density in problems involving floating and sinking. - describe a simple demonstration of the relationship between pressure and depth in a liquid and how this varies with both depth and density of the liquid. - describe applications in living and non-living systems e.g. deep sea animals, barometer, submarines. - know the principle of floatation and apply it to practical examples such as boats, fishes, hot air balloons.

	Speed and acceleration.	<ul style="list-style-type: none"> - know and use the equation: average speed = distance/time taken. - understand and use the relationship: acceleration = change of speed/time. - know and use the relationship that acceleration is proportional to the force acting on a body. - interpret a speed/time graph for linear motion.
	Momentum.	<ul style="list-style-type: none"> - understand and apply the concepts of momentum to the study of moving objects e.g. table tennis ball compared to a stone; a bullet thrown or fired by a gun. - know and apply Newton's Laws of Motion and understand the concept of force as rate of change of momentum. - derive $F = (mv - mu)/t$ and understand impulse as $Ft = mv - mu$. - differentiate between mass and weight and explain their relationship. - know that the gravitational force exerted on 1 kg at the Earth's surface is about 10N. - understand and apply the principles of conservation of linear momentum.
	Work, energy and power.	<ul style="list-style-type: none"> - review the concepts and units of work, energy and power from ISC 115. - derive the expressions $KE = 1/2mv^2$ and $PE = mgh$, and apply them to examples.
	Motion in a circle.	<ul style="list-style-type: none"> - understand that uniform motion in a circular path implies acceleration directed towards the centre of the circle. - know and apply the concept of angular velocity to circular motion. - apply Newton's Laws of Motion to the circular motion of real objects; e.g.. satellites, charged particles in an electric field etc. - explain centripetal force and its relationships to the radius of circular movement and the production of artificial gravity.
	Simple harmonic motion.	<ul style="list-style-type: none"> - know and apply the concept of Simple Harmonic Motion (SHM) as motion of a particle whose acceleration is proportional to its displacement from its mean position and is always directed towards it. - know the meaning of the terms amplitude, frequency and period with respect to SHM, and the energy associated with SHM. - apply the principles of SHM to practical examples e.g. the simple pendulum and oscillating mass on a spring in a qualitative manner.
ISC 216: ENERGY AND PARTICLES. (YEAR 2)	Kinetic theory.	<ul style="list-style-type: none"> - know the molecular theory of cohesion and adhesion and its application to the phenomena of capillarity, surface tension and viscosity with examples from nature e.g., movement of water in plants and soils, formation of rain drops and bubbles and objects falling in fluids e.g. parachutes, terminal velocity. - use the kinetic theory to explain: <ul style="list-style-type: none"> conduction of heat; thermal expansion of solid; the pressure/temperature relationship of gases; change of state; surface tension/temperature relationship; viscosity/temperature relationship.

	Conservation of energy.	<ul style="list-style-type: none"> - know the indestructible nature of energy. - know the tendency for energy to degrade to the form of heat; the second law of thermodynamics and the concept of entropy (qualitative only). - know some applications of the above to real systems e.g. chemical reactions, living systems, mechanical systems.
	Radioactivity.	<ul style="list-style-type: none"> - know that some atomic nuclei can randomly emit radiation, that such atoms are radioactive, and that energy is released when they decay. - appreciate that radiation is a naturally occurring phenomenon. - describe the nature and effects of α, β and γ rays. - understand the consequences of the radioactive decay process in terms of mass number and atomic number (no detailed knowledge of decay series will be required). - know that the naturally occurring radioactive properties of carbon 14 enable it to be used for dating. - understand that matter and energy are inter-convertible; Einstein's equation, $E = mc^2$ - know that the energy released when radioactive materials decay can be harnessed for the production of useful energy (e.g. nuclear power stations and for destructive purposes (e.g. atomic bomb)). - be aware of the problem posed by the waste products of nuclear power stations.
ISC 223: METALS. (YEAR 2)	General properties and reactivity.	<ul style="list-style-type: none"> - Know the general properties of metals and appreciate their economic value related to properties such as conductivity, strength, malleability and ductility. - describe experiments to establish the order of reactivity with water/steam, of sodium, calcium, magnesium, zinc, iron and copper; interpret the results in terms of an order of reactivity.
	Common ores, extraction of metals.	<ul style="list-style-type: none"> - know that the three most common types of metal ore in the earth's crust are oxides, sulphides and carbonates; be able to identify these compounds. - know that copper, iron, aluminium and tin can be extracted from their ores by chemical processes. - describe and explain the process of heating metallic oxides with carbon. - outline the process by which iron is extracted from its ore in a blast furnace.
	Electrolysis.	<ul style="list-style-type: none"> - explain electrolysis; define the terms electrolyte, electrode, cathode and anode. - explain the results of qualitative and quantitative investigations of the electrolysis of aqueous solutions of copper(II) sulphate and of acidified water. - explain Faraday's laws of electrolysis. - explain the application of electrolysis to the extraction of metals. - outline other uses of electrolysis in industry; electroplating, manufacture of sodium hydroxide, reclamation of silver from silver salts.
	Corrosion.	<ul style="list-style-type: none"> - appreciate that corrosion is generally caused by atmospheric oxidation. - describe experiments to determine factors which affect the corrosion of iron and steel. - describe suitable methods for protecting metals against corrosion.

	Elastic properties of solids.	<ul style="list-style-type: none"> - know the effects of external forces on elastic solids; Hooke's law and its limitations, the elastic limit. - know the meaning of tensile stress and strain, Young's modulus as an indicator of material elasticity and strength. - perform simple experiments to determine Young's modulus. - know applications to mechanical and civil engineering e.g. bridge and building construction. - understand the concept of elastic energy e.g. energy of a stretched spring, energy changes in a bouncing ball.
ISC 224: THE EARTH IN THE UNIVERSE. (YEAR 2)	The solar system.	<ul style="list-style-type: none"> - review the content of ISC 127 'the Earth and the Moon'. - outline the scale and details of the solar system and how this was discovered. - know of the presence and properties of space vacuum.
	The Universe.	<ul style="list-style-type: none"> - explain the differences between stars, planets and satellites. - be aware of the existence of galaxies and other stellar phenomena. - give brief outlines of the "big bang" theory of the formation of the universe, as an example of a theory which has gradually gained credence by the accretion of many individual pieces of evidence. - describe the use of astronomical telescopes; and radio telescopes for the detection and tracking of radio wave emitting bodies.
	Air flight.	<ul style="list-style-type: none"> - know simple details of the different methods of heavier than air flight: kites, gliders, aerofoils, helicopters. - appreciate the economic importance of air flight.
	Activities in space.	<ul style="list-style-type: none"> - be aware that aircraft are pressurised to make normal breathing by passengers possible. - know the principles of rocketry and other aspects of space technology. - outline the history, successes and some dangers of space travel. - describe the present activities occurring in space: communication satellites, space shuttle, space station, interplanetary probes. - describe the causes and possibilities of low weight and weightlessness.
ISC 225: FUNDAMENTALS OF LIVING THINGS. (YEAR 2)	The biology of cells.	<ul style="list-style-type: none"> - review the content of ISC 124 (plant and animal cells). - explain the nature and functions of nucleus, cell membrane, cell wall, vacuole, plastids, mitochondria. - compare prokaryotic and eukaryotic cells. - understand cell division and the cell cycle, including mitosis and bacterial cell division. - know the occurrence and functions in the body of the main chemical constituents: <ul style="list-style-type: none"> carbohydrates (monosaccharides, disaccharides and polysaccharides); lipids (triglycerides and phospholipids); proteins (amino acids); nucleic acids. - understand in general terms the replication of DNA. - be aware of the main factors affecting the permeability of cell membranes and the concepts of osmosis, pinocytosis and phagocytosis; plasmolysis and turgor; hypothesis of active transport. - understand the mode of action of enzymes and factors affecting enzyme activity: temperature, pH, substrate/enzyme concentration, inhibitors, coenzymes.

	Chromosomes, genes and variations.	<ul style="list-style-type: none"> - understand the general structure and importance in inheritance of the nucleus. - appreciate the significance of mitosis for genetic stability, growth and cell replacement; and meiosis in sexual reproduction and genetic variation. - exemplify single gene dominance as shown by Huntington's chorea. - understand the expression of the genotype in the phenotype. - understand the meaning and significance of gene pools.
ISC 227: REPRODUCTION AND GROWTH. (YEAR 2)	Sexual reproduction.	<ul style="list-style-type: none"> - understand gametes as specialised cells. - know that sexual reproduction requires the fusion of male and female gametes or form a zygote which develops into an embryo. - identify the ovaries (animal and plant) testes and pollen grains as gamete-producing organs. - appreciate the physical problem of bringing together male and female gametes in plants, fish and mammals. - identify the parts of a simple flowering plant and describe cross-pollination as transfer of pollen from stamen of one plant to stigma of another plant of the same species. - label a diagram of the urinogenital system of a male mammal, showing penis, urethra, testes, sperm tube, scrotum, bladder and seminal vesicle. - identify parts of the female mammalian reproductive system showing vagina, cervix, uterus/womb, ovaries and fallopian tube. - describe in simple terms the monthly cycle of the uterus in preparing for possible pregnancy and the shedding of the spongy lining of the uterus pregnancy does not occur. - know the mode of action and relative effectiveness of "natural". physical and chemical (hormonal) methods of contraception; relation to population control, family and national economies.
	Growth and Development.	<ul style="list-style-type: none"> - label a diagram of the human foetus in situ showing the placental membranes, cord, fluid, wall of the uterus, head and limbs. - know about parturition and lactation; hormonal and neural control of labour, milk secretion and release; benefits of breast feeding. - describe an experiment to investigate conditions required for seed germination. - describe an experiment to investigate the growth of a plant from a seed. - describe an experiment to determine where growth occurs in a root.
ICS 311 & 326: CARBON COMPOUNDS. (YEAR 3)	Introduction to Carbon Chemistry.	<ul style="list-style-type: none"> - know something of the original separation an subsequent unification of organic and inorganic chemistry. - appreciate the unique nature of carbon; catenation, the large numbers of compounds formed and their complexity and importance in living matter. - understand the principles of functional groups and structural formulae (illustrated from the compounds mentioned below). - apply the IUPAC rules to hydrocarbons and their simple substitution products.

	Aliphatic hydrocarbons.	<ul style="list-style-type: none"> - be aware of the fact that carbon compounds can form an homologous series. - know for alkanes: general formula, type of bonding, methods of preparation natural occurrence, combustion, uses as fuels, substitution reactions. - know for alkenes: general formula, methods of preparation, type of bonding, addition reactions of ethene and propene with bromine, hydrogen bromide and sulphuric acid. - know for alkynes: general formula, a method of preparation of ethyne, type of bonding, addition reactions, energy of triple bond with reference to ethyne.
	Crude oil.	<ul style="list-style-type: none"> - know for petroleum: origin, occurrence, composition as a mixture of predominantly aliphatic hydrocarbons. - describe the distillation of crude oil, with approximate proportions and major uses for each fraction. - understand cracking as a way of breaking longer chains to shorter, more commercially useful ones. - know the meaning of the octane number of a fuel. - appreciate ethene as a product of cracking, which is an important source of chemicals for agriculture, medicine and industry.
	Coal	<ul style="list-style-type: none"> - know for coal: origin, occurrence, use as fuel, composition as predominantly carbon, with many useful organic compounds. - know the distillation of coal to release coal gas and coal tar from which important organic compounds are separated, including aromatics such as benzene, phenol, toluene.
	Haloalkanes.	<ul style="list-style-type: none"> - know the nomenclature of the haloalkanes. - understand the polar nature of the bonds. - be aware of the synthetic utility of substitution reactions on haloalkanes e.g. with $-OH$, $-CN$, and $-NH_2$ (restricted the formation of primary amines). - realise the importance and dangers of some organo-chlorine compounds e.g. DDT, PCBs, PVC, CFCs.
	Alkanols.	<ul style="list-style-type: none"> - know the general molecular formula and nomenclature. - know methods for their preparation. - understand what happens when they are oxidised. - know the industrial preparation of ethanol by fermentation and from ethene. - know industrial and domestic uses, including details of methylated spirits.
	Alkanoic acids.	<ul style="list-style-type: none"> - know the general molecular formula and nomenclature. - be aware of naturally occurring acids such as ethanoic and citric acids. - understand the hydrolysis of esters, including saponification; relation to fatty acids, to fats and digestion.
	Amines and amino acids.	<ul style="list-style-type: none"> - know the classes of amines and their nomenclature. - understand the concept of basicity as applied to amines. - know there are different types of amino acids. - know that amino acids have acidic and basic properties. - understand the relationship of amino acids to proteins.

	Synthetic macro-molecules.	<ul style="list-style-type: none"> - understand the concept of polymerisation. - know the nature and uses of addition and condensation polymers e.g. polythene, polyamides and polyesters. differentiate between types of plastics: thermo-plastic and thermo-setting. - appreciate the social and political implications of science and technology in the environment, including the problem of conflict between the need for electrical power and minerals, and the damage that may be caused to the environment. - discuss the effects of science and technology on society in terms of science related occupations and changes in cultural and leisure activities.
ISC 313 & 327: Global Ecology. (YEAR 3)	Socio-political aspects of science and technology.	<ul style="list-style-type: none"> - know possible causes, environmental effects, possible treatments and avoidance of non-communicable diseases e.g. cardio-vascular, cancers, respiratory. - discuss problems of drug abuse, alcohol, tobacco and 'hard' drugs e.g. cocaine and heroin. - review ISC 124 and distinguish between bacteria, viruses and fungi; examples of diseases caused by each; the response of bacteria to antibiotics. - distinguish between methods of disease transmission, with examples: <ul style="list-style-type: none"> air-borne: flu, T.B. etc.; water-borne: cholera, typhoid, intestinal infections; food-borne: intestinal infections; vector-borne: malaria, sleeping sickness; contact: AIDS (including risks blood transfusion), gonorrhoea, syphilis. - understand the basis of innate and acquired immunity; vaccination. - know the schedule of active immunisation in Nigeria. - understand the mechanism of immune response. - understand the bias of antiseptics and disinfection. - discuss preventive medicine, including control of vectors. - know the details of ORT.
	Fuels.	<ul style="list-style-type: none"> - discuss causes and effects of release into the atmosphere of carbon dioxide, sulphur dioxide and lead compounds; the greenhouse effect; means of controlling such emissions. - know the effects of acid rain and formation from burning fuels and from chemical (i.e. fertiliser) plants. - understand how living organisms can act as indicators of pollution. - appreciate the possible contribution of natural and agricultural cropping to current energy needs: biomass as an energy source.
	Food	<ul style="list-style-type: none"> - discuss the use of chemicals as fertilisers and pesticides, advantages and disadvantages; ; cost, dependence, pollution dangers, runoff to water supplies; practicability of biological control of pests. - survey crop improvement methods, seed production and hybrid seeds, seed storage and viability; disease resistant strains; selective breeding and possibilities of genetic engineering, artificial insemination, embryo transplants.
	Water.	<ul style="list-style-type: none"> - know about the effects of pollution by fertilisers, sewage, oil, other organic wastes and heavy metal. - appreciate the potential and real consequences of pollution on food chains. - know some methods of treatment of sewage and other controls on pollution; methods of dispersal of oil slicks. - know about methods for the monitoring of water quality e.g. dissolved oxygen, BOD.

	Waste disposal.	<ul style="list-style-type: none"> - explain the importance of environmental sanitation. - discuss briefly some problems of refuse disposal and state the advantages of using biodegradable materials.
ISC 321: ENVIRONMENT AND POPULATION. (YEAR 3)	Plant succession.	<ul style="list-style-type: none"> - explain the concept of succession. - describe the underlying features of succession: ecological dominance, productivity and biomass.
	Evolution.	<ul style="list-style-type: none"> - understand the concept of organic evolution. - be aware of the evidence for evolution. - understand the mechanism of evolution. - know the major steps in Darwin's theory of evolution through natural selection. - understand mutational changes as causes of evolution. - be aware of present evolutionary trends. - understand the role of fossil evidence in our understanding of human evolution.
	Human population.	<ul style="list-style-type: none"> - understand the effects of birth rate, mortality, immigration and emigration; survivorship curves and growth curves. - understand age pyramids; sex ratios and reproductive values; effects of preventive medicines; care of the infirm and elderly. - be aware of the demographic transition from high to low birth rate in more developed countries as compared with less developed ones.
	Housing.	<ul style="list-style-type: none"> - discuss the importance of housing to human beings. - discuss the importance of choosing good sites for housing. - identify suitable building materials for a given environment, taking account of cost, strength, durability, workability and availability. - explain the importance of proper lighting and ventilation. - identify the various types of toilet systems (pit, bucket, water-system). - discuss the proper use of toilets.
ISC 322: SCIENCE AND SOCIETY. (YEAR 3)	Application of science and technology.	<p>Know and understand the basic scientific principles involved in the design and functioning of the following devices, systems and phenomena:</p> <ul style="list-style-type: none"> - amplifiers; atmospheric phenomena (whirlwinds, tornadoes, mist, rain, hail, thunder, lightning); bridges; building blocks (cement, mud and brick); cassette recorders (audio and video); cinema projectors; clinical thermometer (mercury, electronic and liquid crystal); clothing; computers; cooking pots; ELCB's; electric bulbs and fluorescent tubes; electric cookers; electric kettles; electronic calculators; engines; petrol, diesel and jet; explosives and propellants; flight of birds and insects; fuses and earthing systems; generators; immersion heaters and thermostats; insulation and ventilation in houses, including roof design; laboratory scales; microwave ovens; musical instruments; pressing irons; pumps and siphons; refrigerators, freezers and air conditioners; photography; radar; radio; simple torches; solar energy including collection and use by man; steel railway lines; submarines; telephones systems; television; volcanoes and hot springs; wind and tide energy.

ISC 323: CHEMICAL ENERGETICS. (YEAR 3)	Energy of reactions	<ul style="list-style-type: none"> - explain the meaning of enthalpy changes during a reaction. - explain exothermic and endothermic reactions and their relation to the sign of ΔH. - illustrate Hess's law using simple examples e.g. formation of NaCl or HCl. - explain enthalpies of formations, combustions and neutralisations. - explain enthalpy changes in terms of internal energy.
	Kinetics.	<ul style="list-style-type: none"> - define the rate of a reaction. - know that factors which influence the rate include concentration temperature, light and catalysts. - understand the meaning of order of reaction (distinguished from molecularity). - explain energy of activation in qualitative terms. - give examples of photochemical reactions such as chlorine with hydrogen; photosynthesis; appreciate that the mechanism of photosynthesis is still not fully understood.
	Catalysis/enzymes.	<ul style="list-style-type: none"> - understand catalysts as substances which change the rate of reaction. - distinguish the action of homogeneous and heterogeneous catalysts. - explain on general terms the importance of enzymes as catalysts in biological processes. - describe the effect of the activity of enzymes of yeast in brewing wine making and the rising of bread. - investigate the effect of heat on the activity of enzymes.
	Equilibria.	<ul style="list-style-type: none"> - understand that chemical equilibrium is dynamic. - be aware of the factors which affect the position of equilibrium (temperature, pressure and concentration). - know how to find the equilibrium constant of a reaction given the concentration of the reactants and products; distinguish between K_c and K_p. - apply Le Chatelier's principle to industrial processes e.g. Haber synthesis of Ammonia and the contact process for sulphuric acid.
	Acids, bases and salts.	<ul style="list-style-type: none"> - identify common materials as acidic or basic using universal and/or other suitable indicators. - describe the effect of adding an acid to a base. - explain the meaning of the terms neutralisation and salt. - describe the use of the pH scale as a measure of acidity or alkalinity. - explain the concept of pH in terms of hydrogen ion concentration ($pH = -\ln[H^+]$). - determine the pH of common solutions using indicators and pH meters. - know that water is slightly ionised and the importance of the dissociation constant $K_w = 10^{-14}$. - relate p_H and pOH values to the addition or removal of hydrogen ions. - explain acidity in terms of the Bronsted Lowry theory. - explain the nature of strong and weak acids and bases in terms of dissociation in solution; give examples of each type. - distinguish between acidic, basic and neutral salts; give examples of each kind and relate their p_H to hydrolysis and the strength of their parent acids and bases.

	Redox.	<ul style="list-style-type: none"> - explain oxidation and reduction in terms of increase and decrease in oxidation states by loss and gain of electrons. - investigate simple redox systems and determine half-cell reaction. - write equations for half-cell reaction.
ISC 325: FIELDS AND WAVES. (YEAR 3)	Fields.	<ul style="list-style-type: none"> - define generally: force fields and inverse square law. - apply to magnetic, electric and gravitational fields. - understand the application of force fields to the television tube, man made satellites, natural satellites (e.g. the moon) and the solar system.
	Wave motion.	<ul style="list-style-type: none"> - identify types of waves, longitudinal and transverse, with examples. - understand polarisation of transverse waves e.g. radio waves, light. - know the relationship between velocity, frequency and wave length: the equation $V = n\lambda$. applied to vibrating air columns, radio aerials, resonance. - understand in qualitative terms the Doppler effect and its application to sound and the spectrum of light from receding stars. - know the electromagnetic spectrum in terms of frequency and the applications of the major ranges e.g. radio waves, IR, visible light, UV, X-rays, γ-rays. - know about interference with applications in light, sound and radio waves; illustrated by the use of the ripple tank.
	Electromagnetism.	<ul style="list-style-type: none"> - review current electricity from ISC 226, cells, electrolysis, Ohm's law. - understand that a force acts on a current carrying conductor in a magnetic field. - apply this to the design of the moving coil meter and the DC motor. - know Faraday's and Lenz's laws of electromagnetic induction and their application; to the generation of electricity. - review the generation of electrical power from ISC 226. - understand the advantages of AC for the transmission of electrical energy.

APPENDIX I

UNIVERSITY OF JOS INTEGRATED SCIENCE PROGRAMME TO IMPROVE THE QUALITY OF JSS INTEGRATED SCIENCE TEACHERS IN NIGERIAN SCHOOLS.

ABSTRACT

Since the inception of the 6-3-3-4 system there has been a lack of truly Integrated Science specialists to teach the programme in schools. Single subject specialists have probably tried being assigned to schools to implement the programme. Numerous problems and challenges in aspects such as concept of integration, course structure and scope, attitudes to the programme and resources for teaching course topics have made the implementation of the JSS programme ineffective and the course objectives unattained. This paper presents the University of Jos efforts, programme and course structure for BSC Integrated Science education; concluding with views of the progress, effects, performances and attitudes of Integrated Science students and the challenges the lecturers of the programme have.

**DEPARTMENT OF CURRICULUM STUDIES
FACULTY OF EDUCATION
UNIVERSITY OF JOS
JOS, NIGERIA.
(1991)**

Introduction

A B.Sc (Educ). Integrated Science programme for the production of Teachers for the Junior Secondary Schools (JSS Level) is a crucial issue.

There is no doubt the 6-3-3-4 system would suffer much set-back if deliberate and concerted efforts are not geared towards production of the needed professional power in both quantity and quality to effectively implement it.

One major area of need and challenge is the Integrated Science courses for the pre-primary, primary and junior secondary school levels.

The University of Jos Faculties of Education, Natural Sciences and Geography departments have evolved a new programme for training professional Integrated Science teachers for the J.S.S. level.

Typical in this programme is the new introduction of earth and other geo-science elements into the curriculum. A unique approach of attaining integration has been evolved to ensure (1) beneficiaries of the programme acquire basic concepts, introductory to major higher sciences and not just Biology, Chemistry and Physics - (the so-called basic Sciences); (2) basic knowledge of nature and environment, for the simple understanding of nature and basic skills for understanding and solving of simple problems. More innovative programmes for the production of Trained, Professional Teachers are necessary for the effective implementation of the 6-3-3-4 programmes.

The 6-3-3-4 education system has introduced a new structure and culture into the nation's education programmes. Along with this innovation is the new orientation of introducing the child to basic sciences and developing basic cognitive, affective and manipulative skills in the child early enough to:-

- 1 facilitate later (higher) science learning at the secondary and tertiary school levels, and
- 2 develop some science literacy for living meaningfully and safely in our 20th and even 21st century civilization and in the use of modern technology.

1 RATIONALE

Since the inception of the new policy of Education, the 6-3-3-4 system has ushered in a new need and emphasis of establishing a firm or sound science foundation for promoting specialization in science disciplines, for technological output and scientific literacy towards enlightened citizenry. Through this system, the child is progressively exposed to science concepts, ideas and principles before he is encouraged to specialize in a science discipline or profession of his choice and capability.

Before this new innovation and orientation, there had been provision for education, training and professionalism in the various disciplines only. Emphasis of school curricula had been disciplinary (disciplines emphasis). In response to the call to introduce sciences and develop good science foundation in children, science teachers have only managed the course Integrated Science. There have not been trained teachers in Integrated Science education to handle effectively the Integrated Science course in the Junior Secondary Schools and the Primary Schools of the 6-3-3-4 system.

With the challenge of the new policy and the Integrated Science Foundation need, the Faculty of Education has taken up the challenge to contribute towards development of the needed manpower for the teaching of Integrated Science at Primary and Junior Secondary School levels. The need to train professionals for the teaching of Integrated Science has been also felt and expressed by the Science Teachers Association of Nigeria (STAN) and the challenge has been taken up by a few other Universities such as Ahmadu Bello University, Zaria, which had been preparing to develop and commence a B.Ed Integrated Science Exams from the 1988/89 session.

The B.Sc (Education) Integrated Science degree programme is part of the Faculty of Education response and efforts towards self-sufficiency as urged by the University of Jos.

COURSE STRUCTURE

The curriculum and teaching syllabus have been drawn from a careful consideration of the syllabi of all the departments of science and environmental sciences of University of Jos, namely; BOTANY, ZOOLOGY, CHEMISTRY, PHYSICS, GEOGRAPHY, GEOLOGY AND MINING, MATHEMATICS, REMEDIAL SCIENCE STUDIES and also the FME approved Grade II and JSS Integrated Science syllabi, NCE Integrated Science syllabus of College of Education, Gindiri and A.B.U. Zaria B.Ed Integrated Science course topics proposal.

Since no Integrated Science Degree Syllabus/Curriculum was available for adoption, the science staff of the Faculties of Education and Natural Sciences of the University of Jos took up the challenge and evolved the appended curriculum and teaching syllabus from the university approved science courses, the STAN Integrated Science programmes and syllabus using Professor T. Bajah's modular approach for the structuring and course organization.

The Institute of Education University of Jos offers the Integrated Science certificate (ACE), Diploma and NCE.

The evolved Integrated Science degree programme is not a mere amalgamation of courses from these disciplines and sources but:

- 1 a careful selection and determination of concepts, ideas, themes, skills and attitudes that are interrelative in the basic science disciplines as well as applicative for interdisciplinary understanding, nature study and solution of problems. The subsequently derived courses are coded Integrated Science (Int. Sc.) courses as selected concepts, ideas etc., commonly occurring and used in the various science disciplines. The courses are intended to be taught by the cooperative science specialists' efforts and incorporated seminars for discussing the inter-relativeness of the ideas and their applications in problem-solving.
- 2 a carefully selected set of ideas, concepts and principles that are basic vital information and foundations for higher sciences and scientific professions. These course reflect the basic vital knowledges of life part of nature as exemplified in Botany and Zoology courses; matter or non-living component of nature as exemplified in chemistry, Geography, Geosciences and Physics, the physical factors of forces influencing life and matter as matter and energy exemplified in physics, Geography and Chemistry. These

courses are termed INT. BIO., CHEM., PHY., MATH., GEO., GLY., courses. These courses are supposed to be taught by specialists drawn from the various science disciplines.

3 It was decided that the course structure will take two facets:

- (a) An integrated approach aimed at reflecting science as unity but as also several alternatives to problem-solving.

The approach taken was thematic based on important science themes or ideas but looked at from the different science disciplines such as classification in science, cycles in the various science disciplines.

- (b) The second facet aimed at presenting the pure content (concepts) of science so that the teachers would acquire knowledge on the content of science and the method of teaching the Integrated Science courses.

INTEGRATED SCIENCE METHODOLOGY I AND II OBJECTIVES

This course is offered in two long vacations (vacations I and II) as Int. Sc. Methods I and II with the following objectives:-

- 1 Self preparation of neophyte teachers for the effective planning, organization, management, and teaching of Integrated Science concepts.
- 2 Methods (principle and skills of presenting science as a unity).
- 3 Understanding of biological, chemistry, physical principles in their interrelative nature.
- 4 Developing basic knowledge and understanding of fundamentals of science (skills/Processes).
- 5 Presenting sciences as approaches to problem-solving and the alternatives inherent in each science discipline.
- 6 Laying sound foundation for further science and science applications.
- 7 Training of the needed manpower for the affective teaching and learning of the Integrated Science programme and for teaching/learning of science topics.
- 8 Materials development, selection; improvisations and evaluation of learners' science programme.
- 9 Consideration and discussion of science issues and challenges.
- 10 Promoting thinking and applications of science to life.

EDC 234: INT. SC. METHODS I: PHILOSOPHY OF INTEGRATED SCIENCE

Establishing philosophy of Int. Sc.:-

Description of Integrated Science. Concept and the aims and objectives of integration. Scope and levels of integration. Problems and prospects of integration of sciences. Scientific method and procedure. Rationale for Int. Sc. teaching and learning; the Int. Sc. Curriculum and Syllabus for primary and JSS levels, Science classroom teaching techniques. Teaching syllabus, scheme of work and lesson preparation techniques; Evaluation techniques in science, the school science laboratory; other Facilities' resources for science teaching; use and application of instructional materials.

Innovations, Issues of Integrated Science Programmes.

EDC 334 INT. SC. METHODS II (2 cr)

A follow-up of the EDC 234 aimed at self preparation of the prospective teacher through practical experiences and discussions for proper planning, organisation and management of Int. Sc. lessons and classes as well as wise selection of procedures and materials for teaching. This course will lead to not less than 6 weeks teaching practice. Emphasis area in giving professional training to the prospective teacher include:- consideration of psychological findings and the teacher, comparisons of methods, Teaching/learning of difficult controversial Integrated Science topics, practical improvisation, classroom interaction, language and effective communication in science, more teaching/learning preparations of the prospective teacher, the Integrated Science laboratory; seminar on Issues and problems of Integrated Science teaching.

INTEGRATED SCIENCE COURSE DESCRIPTION

IS 212 MAN, SCIENCE AND SOCIETY		History of science. Man's aims, attempts and objectives to conquer and exploit nature. Man's use of nature. The role of sciences to man and society. Application of science to man, nature, environment and society. Science relationship to economic and political development of man. Historical development of science and technology. Life cycles of protozoa, platyhelminthes, Annelida, Arthropods, Flowering Plants. Geology, man and the environment. Geology in the service of man; geological hazards prevention and monitoring. Alternative historical, cultural and disciplinary views of the man-environment relations and the different explanations for environmental risks and human behaviours. In the study of man-environment relations, the following concepts will be discussed: environmental determinism, possibilism, probabilism and population resource relationships (e.g. the carrying capacity of the land).
IS 216 INTRODUCTORY MATHEMATICS	Algebra	Number system (treated intuitively); Indices, the basic laws, logarithms. Use of tables and machines; Quadratic equations; Induction; Sequences and series; Elementary ideas of convergence (geometric series). Binomial theorem for integer index (simple introduction)
	Geometry	Function, inverse and composite function; algebraic trigonometric and exponential functions.
	Statistics	Permutation, combination, frequency distribution, mean mode Graphical representations.
	Mechanics	Velocity, acceleration, force, Equation of motion. Applications.
IB 221 LIFE I: FOUNDATION OF LIFE AND INTRODUCTORY HISTORY		Introduction to cell Biology and basic biotechniques study. Study of cell, its structure, components and organisation in plants and Animals. Eucaryotic and prokaryotic cells. (Protoplasmic membranes, plastids, cell organelles. The major tissues of the body; histology of major organs and organ systems to Chromosomes morphology, duplication and replication. Mitosis and metosis, Concept of heredity, genotype and phenotype. Introduction to microscopy, specimen preparation, biological drawings.
IC 231 MATTER AND ENERGY II: GENERAL CHEMISTRY		Laws of chemical combination, stoichiometry, calculations. Electronic structure configurations of atoms and elements. Periodic classification of Chemical bonding; ionic, covalent, hydrogen and metallic bonding, hybridisation. Packing ionic crystal lattice. States of matter, elementary kinetic theory, the gas laws, Aqueous solutions; colligative properties, acids, bases, salts, electrolytes, electrolysis. Acidbased equilibria, buffer solution, solubility equilibria, equilibrium constant, calculations. Thermochemistry, bond energies. Qualitative treatment of reaction rates.
IP 241 MATTER AND ENERGY II: GENERAL PHYSICS	Mechanics	International system of Units (SI) Vectors. Newton's laws of motion, Rectilinear and circular motions. Conservation laws. Friction. Centre of mass. Moment of inertia, simple harmonic motion. Newton's law of gravitation surface tension, Hydrostatic pressure, viscosity. Bernoulli's equation, Turbulence, Reynold's number, Elements of elasticity.
	Heat	Laws of thermodynamics. Temperature scales. Specific heat capacity, Latent heat. Ideal gas laws and equation of state, absolute temperature. Elementary kinetic theory. Change of state. Modes of transfer of heat.

	Electromagnetism	Electric Charges field, potential, flux. Gauss's law, capacitance. Direct current, voltage, and resistance, Ohm's law. Joule's law, Kirchoff's law. Magnetic field. Force on current carrying wire in magnetic field. Magnetic moment. Faraday's law of electromagnetic induction. Transformer. Elements of electrochemistry and thermoelectricity. Conduction of electricity in solids, liquids, and gases.
	Optics	Elements of geometric optics, velocity of light. Microscopes and telescopes. Lens equation. Aberration and correction. Photometry. Interference and diffraction of light. Single slit, double slit, grating circular aperture.
I COMM 219 LANGUAGE AND COMMUNICATION IN SCIENCE		A course aimed at teaching developing techniques of effective communication in science lessons; and use of precise but meaningful and logical language in expressing, communicating and writing scientific ideas and reports, methods and strategies of overcoming students' language and communication problems in science. Teacher-pupil effective interaction in science lessons. Techniques of appraising and determining readability of science texts. Language difficulties and nonenclatural procedures in science. Techniques of teaching/learning scientific terminologies.
IS 311 VARIATIONS AND ADAPTATIONS	Adaptive features of organisms	Adaptive radiations in animals and plants. Factors influencing variations. Development of adaptations in animals. Significance of adaptive features. Characteristic features of matter and variations. Behaviour of matter: atoms; electrons, etc. Variations in forms of energy. Variations in geographical factors and influence on variations and adaptations of organisms and phenomena. Characteristic features on various forms of adaptations. General relationships of form/structure to adaptations.
	Adaptations in Geography	The fluvial system - the characteristics of a view channel changing as conditions governing fluvial morphology change, e.g. water supply and sedimentation upstream, underlying river, materials and geomorphic setting. Biogeographical variations in physical environmental factors on plants and animals and the adaptations to such variations. Climatic factors and variations of physical factors.
	Magma	Consolidation of magma in relation to crystallization. Reaction principle and Bowen's reaction series. Metamorphism and its controlling factors.
GLY 217 EARTH MATERIALS AND PROCESSES		The earth and the Solar System. Internal processes in the body of the Earth, i.e. internal heat and formation of igneous rocks. Earth's magnetism and gravity. Surface processes on the skin of the Earth - Weathering, of rocks, formation of soils and sediments. Types of rocks and the rock Cycle. Matter and energy from the Earth, physical properties of minerals and their relationship to crystal chemistry. Bonding isomorphism polymorphism, soil solution etc. Classification of minerals. Economic resources of the Earth, Nigerian Minerals and uses.
GEO 218 INTRODUCTION TO PHYSICAL GEOGRAPHY		Land forms and how they evolve; the measurement of climatic elements and the use of climatic data; the relationship between the major vegetation zones; soil and climate origin of lakes.
IB 222 LIFE II: INVERTEBRATES AND LOWER PLANTS		General biology (Characteristic features, structures and examples) of protozoa, porifers, Coelenterata, Platyhelminthes, Nematoda, Mollusca, Annelida, Arachnida, Crustacea, Myriapoda, Insecta, Echinodermata and of Algae, Fungi, Lichens.

IC 331 MATTER: ORGANIC CHEMISTRY		The Carbon atom and bonding, structural and functional groups, hydrocarbons, carbohydrates properties and reactions, halogen derivatives of alkanes, alcohols, amines, aldehydes, ketones, carboxylic acids, amino acids, simple proteins, benzene compounds and phenols, lower polymers, Preparation, purification and qualitative analysis of organic compounds.
IP 341 MATTER AND ENERGY II: PHYSICS FOR LIFE SCIENCE		The interaction of physics, medicine and Biology; the use of models in physics; friction and its relation to motion of animals forces for a swimming fish. Momentum; impulse; of forces and human performance; specific examples and application. Leg motion in running, fluid pressure caused by angular aule of the inner ear. Elastic behaviour, elastic moduli, stress-strain relations; Application to Bone. Muscle elasticity show; Resonance, vibration to the Ear drum and other applications. Acoustics, Acoustic pressure. Musical acoustics loudness and application. Pressure amplifications and applications in Biology. Heat transfer implications and applications. Membrane potentials in animals; physical properties, principles and applications.
IS 314 EXPERIMENTAL DESIGN AND COMPUTING		Project evaluation and design, experimental methods of sample size; principles of questionnaire design; presentation of results, distributions, means, variance, tests of significance, analysis of variance; correlation of regression analysis; Non-parametric statistics; computer analysis of accumulated data.
GLY 317 INTRODUCTION TO APPLIED GEOLOGY		Introductory geochemistry; application of geochemistry to mineral exploration and dating of rocks; hydrogeology-a quifers and their properties; geological aspects, of site investigation for dam, reservoir building and road construction.
GEO 318 INTRODUCTION TO GEOMORPHOLOG Y		This is an introductory course of lectures in geomorphology - the scientific study of land forms, including their history and processes of origin. The study will include not only those land forms that have developed at or above sea level, but all aspects of the interface between the solid earth, the hydrosphere and the atmosphere. The series of lectures will focus on both the origins and morphology of continental land forms. The course also provides a basic introduction to the concepts and processes in geomorphology. The basic concept of morphogenetic regions will serve the basis of dividing the world into land form regions - Land forms/L-landscapes of (i) tropical, arid and semi-arid regions; (ii) temperate regions; (iii) glacial and periglacial regions; (iv) coastal regions.
IB 321 LIFE 111: ECOLOGY AND HYDROBIOLOGY		Basic principles of ecology:- Niches, food chains, trophic levels, productivity and energy cycling, elements of population ecology, ecological methods, introduction to Community ecology - nature and elimination of communities; community organization, community dynamics; factors limiting the distribution of a species; habitat types in Nigeria and associated plant and animal communities.
	Introduction to population ecology	Interspecific competition. Predation. Plant herbivore systems. Mutualism and commensalism. Natural regulation of population size - impact of some factors. Density relationships. Analysis of population data. Introductory Hydrobiology - Comparative study of conditions, for life in machine brackish and fresh waters; limnology, production of aquatic ecosystems; planktons, periphyton, macrophyton and macro invertebrates; fish Biology and aspects of fish culture; pollution studies including methods of pollution abatement.

IB 322 LIFE III: HIGHER PLANTS AND ANIMALS (CRYPTOGAME AND VERTEBRATES)	Bryophytes and Pteridophytes	Introduction, distribution, morphology and anatomy of the various divisions, Biology gametes. Gymnosperms:- classification and fossil groups. Study of morphology, reproduction of major groups with named examples; development of Seeds.
	Angiosperms	General morphology of root, stem, leaf, inflorescences, flowers, fruits, seeds. Anatomical structures of root, stem, leaf. Pollination. Fertilization. Developments of embryo, germination and establishment of seedlings. 10 selected families of plants and economic importance.
IC 332 MATTER AND ENERGY IV: INORGANIC CHEMISTRY	Chordates	Taxonomy, evolution and general biology of protochordates, fish, amphibia, reptiles, birds and mammals. Periodicity of the elements. Chemistry of hydrogen. Study of the Group I and Group II metals. Oxides, hydroxides halides and aqueous chemistry. Characteristics of the first row transition metals: oxidation states, redox reactions and complexes, chemistry of iron and copper. Extraction of metals from their ores. Study of the Group VII elements and basic chemistry of nitrogen, phosphorous, oxygen and sulphur. Hydrides, oxides, oxo-acids and oxoanions of the non- metallic elements. Elementary qualitative and quantitative analysis.
IS 312 SYSTEMS, ORGANISATIONS AND CLASSIFICATION IN SCIENCE		Basis and basic principles of classification in Biology, Chemistry, Physics, Geography and Geology using examples of solids, metals, chemicals, elements, plants, animals, soils and minerals. Major systems and classes of organisms and matter. Advantages and hierarchy of classifications.
	Basis of Classification in Geography	The basic scientific principles, criteria and procedure employed in geographic classifications with the basic characteristic features of the identified and recognised classes with examples, of land form, river channels, climates, soils and vegetation classifications. Systems organisations, e.g. geomorphic system, structure and complex response and thresholds in geomorphology. Geomorphic system, e.g. drainage basin as process response system.
	The Stratigraphic System	Geological time scale; classification of rocks, and minerals, laboratory and field examination of rocks and minerals; classification of faults and folds.
IS 313 GROWTH IN NATURE	Biological and Physical growths	Biological growths - Nature of growth. Kinds of growth including secondary thickening in plants. The physiology of growth. Factors influencing growth in plants and animals. Significance of growth. Physiology reproduction decay law. Nuclear reactions.
	Geographical growths	The geographical growths that will be treated include: (i) gullies; (ii) wadis and canyons; (iii) sand dunes or deposits, e.g. barchans and seifs, and dust deposits or loess; (iv) beaches and beach ridges; (v) coral reefs and coral islands; (vi) stalactites and stalagmites.

MAT 316 APPLIED MATHEMATICS		Separable equations, Exact equations, first order linear equations. Matrices and determinants. Linear independence of vectors. Systems of differential equations: equations with constant coefficients. Matrix formulation of linear systems. Fundamental sets of solutions non-homogeneous linear systems. The laplace transform. Application of the laplace transforms to solutions of linear equations, the constant coefficients. Cauchy-Enter equations. The variation of constants formula and method of undetermined coefficients. Applications to vibratory and electric circuits and the mixing problems. Continuous random variables, density function. Moments, uniform, exponential and normal distributions. Bivariate moments. Independence. Moment generating functions. Distributions of functions of random variables central lines theorem and law of large numbers.
GEO 418 INTRODUCTION TO CLIMATOLOGY		The course introduces the student to world weather and climate. It treats the processes that involve heat, moisture, and motion in the atmosphere, including weather disturbances and change, the basic concepts of microclimates and the general principles of climatic classification. The student is also introduced to the study of the inadvertent and experimental modification of weather climate, and the basic issues in applied climatology.
IB 323 LIFE IV: CYTOLOGY AND GENETICS		The physical basis of life in procaryotic and eucaryotic organisms; Chromosomes and nuclear division. Mendelism inheritance sex determination and sex linkage; polyploid; extra-chromosomal inheritance. Population genetics: the Hardy Weinberg law; genetic drift; the evolution of dominance. Cell energetics, Biosynthesis Membrane Phenomena and active transport.
IC 431 MATTER AND ENERGY IV: PHYSICAL CHEMISTRY		Heat, work energy, first and second laws of thermodynamics. Phase equilibria single component stems; phase rule. Chemical equilibrium and free energy. Colligative properties, Kinetic theory of gases, non-ideal behaviour of gases, physical properties of gases and liquids, molecular structure and properties of pure substances. Rates of chemical reactions, elementary treatment only.
IP 441 MATTER AND ENERGY IV: OPTICS AND ELECTRODYNAMI CS		Divergence and gradient, divergence theorem, Stokes theorem, introduction to amilinear co-ordinates. Electrostatic field: Gauss theorem of potential energy stored. Capacitors. Dielectrics polarization vector and change displacement. Vector modified canuss theorem, dielectric constant, magnetic dipole moment, Poisson equation, free and bound, charges, Poisson equation; Boundary condition between two dielectric, image charges; Energy of field due to system of charges energy density magnetic fields due to currents, Ampere's law, current density vector, continuity equation. Electro motive force, Maxwell's equation.
	Optics	simulated emission of radiation. Brief introduction to coherence. Einstein coefficient A and B. Population Inversion. theory, method of attainment, rate equations. Resonance cavities. Losses (absorption and diffraction). The gas and solid-state masers Lasers. Gas (incharging Q-switching Norse in Masers and Lasers). Modulators and demodulators of lasers. Masers and lasers for communicative systems. Photography Holograph.
IS 411 CYCLES IN NATURE		Biological, chemical, physical, geographical and geological cycles. Energy/trophic levels.
	Biological Cycles	The biochemical cycles and their significance: food chains, food webs etc.

	Chemical Cycles	Introductory atmospheric Chemistry: The carbon cycle, oxygen, carbon dioxide, Nitrogen, Water cycles, ozone, photochemistry of the atmosphere, air pollution. Soil structure, nutrients, agricultural chemicals added to soil, retention conversion and degradability. Chemicals in the environmental - Effects of crude oil, agrochemicals and industrial effluent on urban and aquatic environments.
	Physical Cycles	Entropy, Carrot Cycle, Rankine, Otto, Diesel Cycles. Magnetic field; Lorentz forces, Faraday's laws. Magnetic induction. Ampere's law. Electro Magnetic waves.
	Geological Cycles	Hydrologic cycle; geochemical cycle; tectonic cycles with particular reference to Africa and Nigeria; major tectonic episodes in geological time, concept of plate tectonics.
	Geographical Cycles	(i) The geographical cycles of erosion (Davis, 1899) and its variants - the arid cycle, the mountain glaciation cycle, the karst erosion cycle, the marine erosion cycle, the savanna erosion cycle, and the periglacial erosion cycle. (ii) The hydrological cycle - The patterns of water's movements and transfers among such major water reservoirs as the oceans, atmosphere and continents
IS 412 CONTINUITY IN NATURE	Origin and Progression of typical plant and animal groups	Historical, evolutionary and structural trends. Inter-relationships between plants and animals. Speciation and natural selection
	Geographical examples	(i) Inter-relationships between physical environmental factors, e.g. soils and water, vegetation (types and numbers), and animals (types and numbers) (ii) The fluvial system: The inter-relationships amongst the governing conditions of the fluvial system and how they influence the outputs of water and sediment discharges and hence continuity of the fluvial system.
IS 412 LIMITATION OF NATURAL RESOURCE AND ECONOMIC SCIENCE		Nigerian biological resources: Conservation of soil, water plants and animals; problems of over exploitation, pollution; management of reserved areas. Resources Management and Land Use Allocation:- Population growth and food production. Game reserves, Game Management and Conservation. Biology and ecology of Game animals. Conservation and Management of Nigerian soils and forests. Environmental pollution. Field trip:- Field project at any Game reserve and/or other site of interest on game management, animal behaviour and ecology.
	Chemical Management	Analytical methods for the determination of toxic chemicals in the environment. Energy: Sources of energy, alternative methods of production, environmental effects; Waste disposal, environmental safety considerations. Environmental resources management and land use allocation - renewable and non-renewable resources and their management. The concepts of preservation and conservation of such natural resources as: (i) water - ground and surface waters; (ii) soil erosion phenomena (gully erosion, rill erosion and sheet erosion) and the combating of this phenomenon; (iii) natural vegetation depletion and conservation principles; (iv) the problem of desertification/desert encroachment and its management; (v) minerals, fuels and energy resources : "Ore" and "gangue" minerals; process of formation of mineral deposits; economic deposits, of Nigeria; techniques for extraction of Ore reserves using local example(s).

IB 421 LIFE V: EVOLUTION AND ADAPTATION		Variation in natural populations
	Evolution in plants	History of paleo-ba-any: fossil members of gymnosperms and pteridophytes. The evolution of early grains. Fossil pollen grains. The uses of pollen grain in forensic science.
	Evolution in animals	Characteristics and biology of primates; development of bipedalism and increasing brains size; fossil history of man. Other evidences of evolution. Evolutionary theories of e.g. Darwin and Lamarck.
IC 432 MATTER AND ENERGY IV: ANALYTICAL CHEMISTRY		Types of analysis, error and statistics, precision and accuracy. Comparison of results and sampling. Theoretical aspects of titrimetric and gravimetric analyses with relevant practicals (i.e. food, drugs, rocks and soils, raw potable and waste water, chemical samples, and colorimetric). Elements of electronic structure of atoms and molecules.
IP 442 MATTER AND ENERGY IV: Introductory Geophysics		Geophysics as a discipline; major sub-divisions and examples - physical properties of solid earth materials:- Mechanical, thermal electrical properties and others. Geophysical survey methods. Physical structure of the earth and methods of examining the earth structure with examples.

APPENDIX J

FACULTY OF EDUCATION
DEPARTMENT OF EDUCATION
AHMADU BELLO UNIVERSITY, ZARIA.

4 - Year Degree in Science Education.

The science Education Section of the Department of Education prepares students for the award of the B.Ed Science (i.e. B.Ed) Biology, B. Ed. Chemistry, B.Ed. Geography, B.Ed. Physics, and B.Ed. Integrated Science degrees.

General Aims.

The emphasis of the B.Ed. Science will be the preparation of teachers to teach science subjects (biology, chemistry, physics or geography in the senior secondary schools, colleges of education or colleges of arts and science. While the B.Ed. integrated science degree programme will train integrated science teachers for junior secondary schools.

The graduates of both programmes should be able to assume positions of administrative responsibility in schools, teacher colleges and Ministries of Education as science specialists.

Instructional Objectives:

Cognitives:

Graduates of both options (B.Ed. Science and B.Ed. integrated science) should be able to:

1. Comprehend and apply ideas put forward in the study of the Foundation of Education, so as to solve specific problems related to science education in schools.
2. Master satisfactorily the concepts and principles in science needed for effective science teaching.
3. Acquire and apply basic concepts of curriculum and instruction to science teaching.
4. Acquire the concept of the fundamental unity of science.
5. Acquire and use the basic principles of educational inquiry.

Skill Objectives:

1 Through an appropriate combination of expository, discovery/inquiry and other teaching strategies the graduates of both programmes should be able to help students learn science through the:

- (a) effective planning and teaching of science using activity based methods.
- (b) identification and use of local resources in science lessons.

(c) designing and conducting of simple science experiments.

2. They should acquire, practice and perfect the process skills needed for effective science teaching.

3. The graduates should be able to design and conduct research on problems related to science teaching in school and colleges.

Affective:

1. Graduates should have developed an appreciation of the ethical rules of science viz: empiricism, open mindedness, parsimony, tentativeness etc..

2. They should acquire the spirit of inquiry and an appreciation of creativity through an exploration of the environment.

3. Graduates should understand and appreciate the role of science in everyday life.

4. They should value and recognise aspects of the cultural environment.

5. They should appreciate the need for scientific literacy.

THE PRESENT STRUCTURE OF THE INTEGRATED SCIENCE COURSE AT AHMADU BELLO UNIVERSITY, ZARIA.

FIRST YEAR.

Course NO.	Course Title	Credit Units 1 st Semester	Credit Units 2 nd Semester	Status	Location
SGRS		4	4	Core	SGRS
EDUC 101	Educational Foundations	2	-	"	Educ Dept.
BIOL 111	General Biology	2	-	Cognate	Fac. of Science
BOTY 121	Plant Biology	2	-	"	"
CHEM 111	General Chemistry	2	-	"	"
CHEM 121	Introductory Organic Chemistry	2	-	"	"
CHEM 191	Introductory Practical Chemistry	1	-	"	"
GEO 101	Man Location and Resources	2	-	"	"
EDUC 102	Introductory Psychology	-	2	"	Educ. Dept
BIOL 112	General Biology II	-	2	"	Fac. of Science
BOTY 122	Plant Biology II	-	2	"	"
PHYS 111	Mechanics	-	2	"	"
PHYS 122	Electricity, Magnetism and Modern Physics		2	"	"
PHYS 160	General Physics Practicals	-	1	"	"
MATH 100	Basic Mathematics	-	2	Restricted Elect.	"
GEO 102	Man Location and Resources II	-	1	"	"
SGRS 105	Use of Library	1	-	"	SGRS
		18	18		

SECOND YEAR

Course NO.	Course Title	Credit Units 1 st Semester	Credit Units 2 nd Semester	Status	Location
SGRS 200	Moral Philosophy	1	1	Core	SGRS
EDUC 201	Sociology of Education	2	-	"	Educ. Dept
EDUC 202	Educational Psychology	2	-	"	"
EDUC 203	Curriculum and Instruction	2	-	"	"
EDUC 204	educational Psychology	-	2	"	"
EDSE 205	Subject Method	-	2	"	"
EDSE 221	Lab. Technique and Management	2	-	"	"
EDSE 222	Philosophy of Integrated Science	2	-	"	"
ZOOL 131	Animal Biology I	2	-	"	Fac. of Science
ZOOL 132	Animal Biology II	-	1	"	"
BIOL 214	Introduction Cytogenetics	3	-	"	"
ZOOL 234	Animal Physiology	-	2	"	"
BIOL 212	General Ecology	-	2	"	"
GEOG 104	Man's Physical environment I	2	-	"	"
CHEM 121	Introductory Inorganic Chemistry	-	2	"	"
CHEM 131	Introductory Organic Chemistry	-	2	"	"
PHYS 131	Heat and Properties Matter	-	2	RE*	"
PHYS 260	Physics Workshop Practice I	-	2	RE	"
COSC 101	Programming in Basic	-	2	Core	SGRS
		18	20		

*RE - Restricted Elective

THIRD YEAR

Course NO.	Course Title	Credit Units 1 st Semester	Credit Units 2 nd Semester	Status	Location
EDUC 300	Elementary Statistics	2	-	Core	Educ Dept
EDUC 301	Educational Research Methods	-	2	"	"
EDCI 302	Curriculum Studies I	2	-	RE	"
EDCI 303	Curriculum Studies II	-	2	"	"
EDUC 208	Studies in Foundation of Education	-	2	Core	"
EDUC 309	Introduction to Guidance and Counselling	-	2	"	"
EDSE 312	Classification in Science	2	-	"	"
EDSE 313	Variation and Adaptation	-	2	"	"
EDSE 322	Micro Teaching	-	1	"	"
EDSE 325	Cycles in Nature	2	-	"	"
EDSE 326	Growth and Change	-	2	"	"
EDSE 327	Systems and Organisation	-	2	"	"
BOTY 224	Plant Physiology I	2	-	"	Fac. of Science
BIOL 313	Metabolic Physiology	-	2	"	"
BIOL 314	Evolution and Adaptation	1	-	"	"
PHYS 123	Geometric and Wave optics	-	1	"	"
PHYS 360	Physics Workshop Practice II	-	2	"	"
CHEM 211	General Chemistry	2	-	"	"
CHEM 221	Inorganic Chemistry	2	-	"	"
CHEM 291	Practical Chemistry I	2	-	RE	"
EDUC 207	Instructional Technology	2	-	Core	Educ Dept
		19	20		

FOURTH YEAR

Course NO.	Course Title	Credit Units 1 st Semester	Credit Units 2 nd Semester	Status	Location
EDSE 400	Teaching Practice	9	-	Core	Educ Dept.
EDSE 401	Project	3	-	"	"
EDSE 421	The Teaching of Primary and Integrated Science	-	3	"	"
EDSE 423	Environment Management	-	3	"	"
EDSE 424	Continuity in Nature	-	2	"	"
EDSE 425	Integration of Matter in the Environment.	-	2	"	"
EDSE 426	Limitation of Natural Phenomena	-	2	"	"
EDSE 427	Integrated Science Programmes	-	2	"	"
CHEM 212	Physical chemistry	-	2	"	Fac. of Science
BIOL 318	Soil Biology	-	2	RE	"
EDUC 402	Measurement and Evaluation	-	2	Core	"
		12	17		

SUMMARY:

CORE/COGNATE:	120 Credits
ELECTIVE	20 Credits
	<hr/> 140 Credits

APPENDIX K

LIST OF SAMPLE SCHOOLS, COLLEGES AND UNIVERSITIES

A: SCHOOLS

CODE	NAME OF SCHOOL	TYPE OF SCHOOL
A	Government college Amper	State Govt - Mixed
B	Federal Govt Girls' College, Langtang	Fed. Govt - single-girls
C	Government secondary school, Kwanpe	State Govt - Mixed
D	Federal Government College, Jos	Federal Govt - Mixed
E	Government College, Jos	State Govt - Mixed
F	Nakam Memorial Sec. School, Panyam	Voluntary Agency - Mixed
G	Mwaghavul Community Sec. Sch., Pushit	Volunt. Agency - Mixed
H	Government Secondary School, Pankshin	State Govt - Mixed
I	Government College, Pankshin	State Govt - Single-boys
J	Yakubu Gowon's College, Sharam	Private - Mixed
K	Government Secondary School, Jos	State Govt - Mixed
L	Government College, Gindiri	State Govt - Mixed
M	Girls High School, Gindiri	V/Agency - Single-girls
N	Boys Secondary School, Gindiri	V/Agency - Single-boys
O	Mada Hills Secondary School, Akwanga	V/Agency - Mixed
P	Government Secondary School, Kufang	State Govt - Mixed
Q	Government Secondary School, Kanadap	State Govt - Mixed
R	Government Special Science School, Kuru	State Govt - Single-boys
S	Government Secondary School, Shendam	State Govt - Mixed
T	Government College, Garkawa	State Govt - Mixed
U	Mangu Secondary School, Mangu	Private - Mixed
V	Government College, Langtang	State Govt - Mixed
W	Government Secondary School, Langtang	State Govt - Mixed
X	Govt Girls Science School, Shendam	State Govt - Single-girls
Y	Unijos Demonstration Sec School, Jos	Voluntary Agency - Mixed

B: COLLEGES AND UNIVERSITIES

CODE	COLLEGE/UNIVERSITY
A	College of Education, Akwanga
B	College of Education of Ankpa
C	College of Education, Gindiri
D	College of Education, Katsina Ala
E	Federal College of Education, Pankshin
F	Federal College of Education, Zaria
G	University of Jos
H	Ahmadu Bello University, Zaria

APPENDIX L

Table A: Age distribution among classroom teachers of integrated science.

AGE GROUP	MALES	FEMALES	FREQUENCY	PERCENTAGE
20 - 24	3	2	5	9.6
25 - 29	12	6	18	34.6
30 - 34	7	7	14	26.9
35 - 39	6	5	11	21.2
40 - 44	1	2	3	5.8
45 - 49	1	0	1	1.9
50 & above	0	0	0	0
TOTAL	30	22	52	100

Table B: Years of Teaching Experience among Practising Teachers of Integrated Science.

	MALE	FEMALE	FREQUENCY	PERCENTAGE
1-3 Yrs.	19	10	29	55.8
4 - 9 "	8	8	16	30.8
10 & Above	3	4	7	13.4
TOTAL	30	22	52	100

Table C: Training Received by Teachers of Integrated Science

	MALE	FEMALE	FREQUENCY	PERCENTAGE
FORMAL	7	5	12	23.1
INFORMAL	8	7	15	30.8
NO TRAINING	14	10	24	46.1
TOTAL	29	22	51	100

APPENDIX M

PRACTISING TEACHER BACKGROUND INFORMATION

TR.	SCHOOL TYPE/LOCATION	SEX	Age Grp	QUALIFICATIONS	O'Level Science Subjects	Experience	I.S.C. Training
1	State Govt/Mixed/Rural	M	35-39	WASC/GCE, B.Ed, M.Ed	Chem, Bio, Phy, Maths, Agric. Sc.	10	Informal
2	State Govt/Mixed/Rural	M	40-44	Grade II, NCE, B.Ed	Maths, Agric. Science, G/Science, PHE	2	none
3	Fed. Govt/Single-girls/Sub-urban	F	20-24	WASC/GCE, NCE	Maths., Chem, Bio.	3	none
4	State Govt/Mixed/Rural	F	30-34	Grade II, NCE	Chem, Bio, Phy, Agric. Sc., Int.Sc., PHE	1	none
5	State Govt/Mixed/Rural	M	35-39	Grade II, NCE	Chem, Bio, Phy, Agric. Sc., Int.Sc., PHE	2	none
6	Fed. Govt/Mixed/Urban	F	25-29	WASC/GCE, HND, B.Ed	Chem, Bio, Phy, Maths	3	none
7	State Govt/Mixed/Urban	F	35-39	WASC/GCE, B.Sc.(Ed)	Chem, Bio, Phy.	13	Formal
8	State Govt/Mixed/Urban	F	40-44	WASC/GCE, B.Sc., M.Sc.	Chem, Bio, Phy.	11	Informal
9	State Govt/Mixed/Urban	F	30-34	WASC/GCE, B.Sc.	Chem, Bio, Phy, Maths	7	Informal
10	Voluntary Agency/Mixed/Rural	M	25-29	WASC/GCE, NCE	Maths, Chem, Phy, H/Science	3	none
11	Voluntary Agency/Mixed/Rural	M	25-29	WASC/GCE, NCE	Chem, Bio, Phy.	1	Formal
12	Voluntary Agency/Mixed/Rural	M	30-34	WASC/GCE, NCE	Chem, Bio, Phy, Maths, Agric. Sc.	2	Formal
13	Voluntary Agency/Mixed/Rural	M	25-29	Grade II, NCE	Maths, Bio, G/Science	1	Informal
14	State Govt/Mixed/Sub-Urban	M	20-24	WASC/GCE, NCE	Chem, Bio, Agric. Sc.	1	Formal
15	State Govt/Single-boys/Sub-Urban	F	30-34	Grade II, NCE	Agric.Sc., H/Science	7	Formal
16	State Govt/Single-boys/Sub-Urban	F	25-29	WASC/GCE, B.Sc.	Chem, Bio, Phy, Maths	3	none
17	State Govt/Single-boys/Sub-Urban	F	20-24	WASC/GCE, B.Sc.(Ed)	Chem, Bio, Phy., Agric. Sc.	1	none
18	Private/Mixed/Rural	M	25-29	WASC/GCE, NCE	Chem, Bio, Phy, Maths	3	Formal
19	Private/Mixed/Rural	F	30-34	WASC/GCE, B.Sc., PGDE	Chem, Bio, Phy.	8	none
20	State Govt/Mixed/Urban	F	35-39	WASC/GCE, GD II, NCE, B.Ed	Chem, Bio	3	none
21	State Govt/Mixed/Rural	M	25-29	WASC/GCE, HND	Chem, Bio, Phy, Maths	2	Informal
22	State Govt/Mixed/Rural	M	30-34	WASC/GCE, HND	Chem, Bio, Phy, Maths	4	none
23	State Govt/Mixed/Rural	M	25-29	WASC/GCE, NCE	H/Science	5	Informal
24	Voluntary Agency/Single-girls/Rural	M	20-24	WASC/GCE, NCE	Chem, Bio, Phy, Maths, Agric. Sc.	1	none
25	Voluntary Agency/Single-boys/Rural	M	25-29	WASC/GCE, NCE	Chem, Bio, Phy, Maths, Agric. Sc.	3	Informal
26	Voluntary Agency/Single-boys/Rural	M	35-39	WASC/GCE, NCE	Chem, Bio, Phy.	7	none
27	Voluntary Agency/Mixed/Sub-Urban	M	20-24	WASC/GCE, NCE	Chem, Bio, Agric. Sc., Maths	1	Formal
28	State Govt/Mixed/Urban	F	35-39	Grade II, NCE	Maths, Bio, Phy	5	Informal
29	State Govt/Mixed/Urban	F	35-39	Grade II, NCE	Bio, Chem, Maths	6	Informal
30	State Govt/Mixed/Urban	M	25-29	WASC/GCE, NCE	Chem, Bio, Phy, Maths	3	Informal
31	State Govt/Mixed/Urban	M	35-39	Grade II, NCE	G/Science	5	Informal
32	State Govt/Boys' special Sc. Sch./Sub-Urban	F	25-29	WASC/GCE, NCE	Bio, Chem, Maths	1	Informal
33	State Govt/Boys' special Sc. Sch./Sub-Urban	F	30-34	WASC/GCE, GD II, NCE	Chem, Bio, Phy, Maths	1	Formal
34	State Govt/Boys' special Sc. Sch./Sub-Urban	F	25-29	WASC/GCE, NCE	Chem, Bio, Phy, Maths	2	Formal
35	State Govt/Boys' special Sc. Sch./Sub-Urban	M	45-49	WASC/GCE, GD II, NCE	Chem, Bio, Phy, Maths, Agric. Sc.	10	Formal
36	State Govt/Boys' special Sc. Sch./Sub-Urban	M	25-29	WASC/GCE, B.Sc.	Chem, Bio, Phy, Maths, Agric. Sc.	1	none
37	State Govt/Mixed/Sub-Urban	F	25-29	Grade II, NCE	Maths, G/Science, PHE	5	none
38	State Govt/Mixed/Rural	M	30-34	Grade II, NCE	G/Science	3	none
39	State Govt/Mixed/Rural	M	30-34	WASC/GCE, B.Sc.(Ed)	Chem, Bio, Phy., Agric. Sc.	5	none
40	Private/Mixed/Sub-Urban	M	25-29	WASC/GCE, B.Sc.	Chem, Bio, Phy, Maths, Agric. Sc.	1	none

41	Private/Mixed/Sub-Urban	M	25-29	WASC/GCE, NCE	Chem, Bio, Phy, Maths, Agric. Sc.	2	none
42	State Govt/Mixed/Sub-Urban	F	30-34	Grade II, NCE	Agric. Sc., G/Science, H/science	1	none
43	State Govt/Mixed/Sub-Urban	M	35-39	Grade II, NCE	G/Science, H/Science	10	Informal
44	State Govt/Mixed/Sub-Urban	M	25-29	WASC/GCE, NCE	Chem,Bio, Phy, H/Science	3	Formal
45	State Govt/Girls' special Sc. Sch./Sub-Urban	F	30-34	Grade II, NCE	G/Science, H/Science	1	Informal
46	State Govt/Girls' special Sc. Sch./Sub-Urban	F	25-29	Grade II, NCE	Agric.Sc., G/Science	4	Formal
47	State Govt/Girls' special Sc. Sch./Sub-Urban	M	30-34	WASC/GCE, B.Sc.	Chem, Bio, Phy, Maths, Agric. Sc.	2	none
48	State Govt/Girls' special Sc. Sch./Sub-Urban	M	30-34	WASC/GCE, B.Sc.	Chem, Bio, Phy, Maths	5	none
49	Private/Mixed/Urban	F	35-39	WASC/GCE, B.Sc.(Ed), M.Ed.	Chem, Bio, Phy, Maths	10	none
50	Private/Mixed/Urban	M	30-34	WASC/GCE, HND	Chem, Bio, Phy., Agric. Sc.	4	none
51	Private/Mixed/Urban	F	40-44	WASC/GCE, B.Sc.(Ed), M.Ed.	Chem, Bio, Maths	21	Informal
52	Voluntary Agency/Mixed/Sub-Urban	M	35-39	Grade II, NCE	G/science, H/science	5	informal

TR.- Teacher.

I.Sc - Integrated Science.

GCE- General Certificate of Education

WASC- West African School Certificate

Gd II - Grade Two Teachers' Certificate.

NCE - Nigerian Certificate of Education

HND - Higher National Diploma

B.Ed- Bachelor of Education

M.Ed - Master of Education

APPENDIX - N

COMPETENCIES FOR AN INTEGRATED SCIENCE TEACHER.

N[a]

During the 1973 Maryland conference on the education of teachers for integrated science, a working group also came up with the following list of competencies required of a teacher of integrated science(Bajah, 1989). That the integrated science teacher should:-

1. have an acquaintance with different materials for the teaching of integrated science and be able to identify differences and similarities in their aims and philosophy.
 2. be able to suggest and set up suitable experiments from available materials and be able to guide students to do them.
 3. be able to carry on an inquiry-oriented teaching programme and be able to participate in class with children in discussion etc., as a group leader and 'facilitator' to sources of information.
 4. strive for unity in knowledge of all kinds, and convey this attitude to his students.
 5. recognise the expertise that others have to offer, welcome their contributions and hold high standards of performance for himself and his students.
 6. have some minimum knowledge of science and understanding of its role in the lives of the people in the community.
-

A working group discussion during the Nijmegen conference, Netherlands, 1978, was centered on the development of some desirable attitudes in teachers of integrated science. The outcome of the forum, reported by Cingel and Yoong(1979) included:

1. the need for the teacher to look beyond the confines of scientific content requires an adjustment of attitude.
 2. the teacher should understand and show interest in the culture, interests, language and values of the pupils.
 3. they must be helped to acquire economic, political and agricultural sensitivity in relation to scientific activity for they might be required to discuss the notion of 'quality' of life, for example, in relation to decision-making in the resolution of persistent human problems.
 4. the teacher of integrated science should develop a 'non-defensive teaching style' so as to facilitate inter-disciplinary activities with colleagues and to gain cooperation from pupils.
-

A Technical Working Group convened by UNESCO in the Philippines in 1984 under the auspices of the Asia and the Pacific programme of Educational Innovation for Development(APEID) identified some competencies and attitudes which it believes are needed by both teachers of science and science teacher educators. Its proposal of these competencies and attitudes were based on the concept of 'open competence', a term which emerged from the Seventh Regional Consultation Meeting on APEID (Bangkok, June, 1981). Further discussion on the concept of open competence by a Study Group Meeting on Science Curriculum and Instructional Materials Development (Bangkok, Nov. 1981), observed that:

We are in an age of rapid changes in the natural sciences and social situations. In order to adapt to the rapidly changing and progressing age

and to contribute to the socio-economic progress, is it important for all the students to acquire certain competencies and attitudes to solve problems and think creatively. For education to assist in this, school science education programmes will have to provide for teaching-learning experiences through a variety of methods which will help develop concepts and skills which are flexible and applicable to a wide variety of situations rather than limited in scope.

The position expressed here agrees with what Showalter sees as a relevant competency for the science teacher when he says that the teacher of science should:

be more concerned with helping students learn the relatively few major concepts, processes and values that permeate all sciences than with students acquisition of large number of facts which have limited usefulness in place and time.

The group further suggested the following as an illustrative list of open competencies that needs to be built into the students and which have obvious implications for the training of science teachers:

- (a) Process skills (Scientific Methods): These include, observation, measurement, recording, inferring, designing and conducting of experiments, data interpretation, making assumption, formulating hypotheses and testing, controlling variables and isolating, formulating models and communicating skills (including use of symbols, graphs etc.)
- (b) Knowledge: Understanding and use of concepts, laws or principles, formulas, symbols and signs; knowledge of methodology and mathematical skills.
- (c) Way of thinking: Deductive, inductive, analytical, synthetical, divergent, convergent, intuitive, imaginative and creative.
- (d) Attitudes: Self-reliance, positive self-confidence or self-concept on his or her judgement of ideas with respect to science and science learning; respect for others' judgement and ideas; patience or tolerance for differences and disagreements from others; courage and willingness for taking the responsibility for his/her judgement and ideas; sensitivity to changes and new problems; awareness of social and national development; and love for nature as well as human beings.
- (e) Values: Seeing science as an important part of our culture, seeing science as an approach to solve human and social problems; seeing science as a process as well as a product; understanding or recognising science as the creation of comparative work;

seeing science as a critical factor for the improvement of human welfare as well as the technical development; and judging on the basis of sound evidence.

In a subsequent examination of the requisite competencies and attitudes of the science teacher as a sequel to those listed above for students, the group identified four major processes under which these competencies can be subsumed. They are:

- Information Processing.
- Problem-solving.
- Creativity.
- Decision-making.

Information processing:

In the light of the ever-increasing explosions of scientific information inundating all areas of studies, the innovative science teacher of today needs the specific competencies to ascertain his or her information needs and the nature as well as the scope of the information needed (UNESCO,1985).

The competencies associated with information processing were listed as the ability to:

- identify, locate and utilise sources of information(sources of information include standard textbooks, library resources, computerised programmes, community resources, the various forms of the media etc.
- classify, analyse and utilise relevant information(in collecting and recording information, basic skills like classifying fact and concepts, making abstracts, annotations and bibliographies and essential.
- simplify scientific information from the primary sources to the level of the target group(teacher should have the competencies to extract and simplify scientific information to the level of the students.
- be familiar with the use and application of newer technologies(teacher should possess some familiarity with the use, application and simple maintenance of hard and softwares).

Problem-solving.- In the context of science education, problem-solving usually entails performing the steps of the scientific methods (UNESCO, 1985). Problem-solving is a process where previously learned rules and concepts are applied in finding solutions to a

variety of real life and simulated situations which lend themselves to the application of the scientific methods (Campa R.F. et al, 1983).

The following competencies were outlined as relevant to developing problem-solving (UNESCO op cit.):

- sensing, recognising and defining the problem.
- hypothesising.
- determining the type of study.
- judging the adequacy and accuracy of information and data.
- communicating results of the inquiry.

For **Creativity**, it was observed that educators and psychologist have grappled with the attributes of creativity. The UNESCO report however, in attempt to give the picture of the demand of creativity explained that normal children by their very nature are curious and the teaching and learning of science has rich potentials to encourage and develop this trait. Curiosity, the report added, is the main driving force for creativity. Substantiating, the report asserts that, episodes from the history of science and technology amply demonstrate that curiosity has been the main source of discoveries in science and technology. Science teachers have therefore an important role to play in fostering and sustaining the natural curiosity of children which leads to creativity.

A study by Baez(1980) concluded that creative people exhibit the following behaviours:

- challenge assumptions.
- see in new ways.
- recognise new patterns.
- make new connections.
- construct new networks.
- take risks.
- take advantage of chance.

He also sees a creative individual as one who:

- exhibits high-level curiosity;
- thinks originally, flexible, divergently, and imaginatively;

- is able to elaborate;
- is able to improvise, innovate and invent;

The UNESCO report listed the following competencies which it believes would help the science teacher to promote creativity. It include the ability to:

- identify creativity-promoting settings from local situations;
- identify and utilise episodes from the history of science;
- identify unsolved problems and problems with multiple solutions;
- design and provide learners with investigative type of learning episode;
- identify and utilise issues of multi-disciplinary nature for classroom discussions;
- take calculated risks;
- synthesise ideas and apply techniques of system analysis;
- ask probing, analytical and open-ended questions in order to arouse curiosity.

In relation to **Decision-making**, the UNESCO report made the following observation:

“The interaction of science, technology and society has brought into focus the increasing importance of decision-making competencies and attitudes for the teacher and students. Many decisions are made at the community, national or international level involving the application of science through technology e.g., construction of power plants; use of pesticides, herbicides, food additives; nuclear weapons; pollutants from industries, which may be far-reaching, long-term societal implications in terms of health, economic, political and cultural consequences”.

The report believes that, most often than not, such important decisions affecting problems of this nature are made without following the steps of rational decision-making.

I guess, the reasons for this are largely due to lack of relevant competencies.

Holford (1983), UNESCO (1985), provided the following sets of competencies for rational decision-making which should be developed in science teachers:

- Recognising the social consequences and responsibilities of the development of scientific and technological possibilities.
- Objectively appraising available information and rationally analysing the long-term environmental and social consequences of alternate possibilities for action or restraint.
- Communicating the consequences effectively and with the urgency for gaining public attention to significant decisions.

- Teaching applications of science through technology in society in such a way that pupils are helped in forming defensible opinions on science-related societal issues.
- Fostering pupils' growth in decision-making in a participative manner.
- seeking connections between science and technology in science lessons.

It is my opinion that these four major elements of open competence reviewed above (information-processing; problem-solving; creativity; and decision-making) do overlap and are intricately interlinked. For instance, information-processing is needed in all the three other elements which all require a knowledge base; problem-solving competencies such as those used in interpreting data and gathering, facilitate making new patterns, connections and networks. Conversely, creativity is needed in problem-solving to arrive at novel or alternative solutions. A certain amount of decision-making is involved in problem-solving as in evaluating the adequacy and accuracy of data, and in rejecting or not rejecting a hypothesis. Thus the interrelatedness of the elements must be considered in developing the competencies.

